DARTMOUTH
Engineer
SUMMER 2020
THAYER SCHOOL OF ENGINEERING

WHY PUBLIC POLICY NEEDS DARTMOUTH ENGINEERS

THE VALUE OF SYSTEMS THINKING IN PUBLIC POLICY TO HELP ADDRESS SOME OF TODAY'S TOUGHEST CHALLENGES

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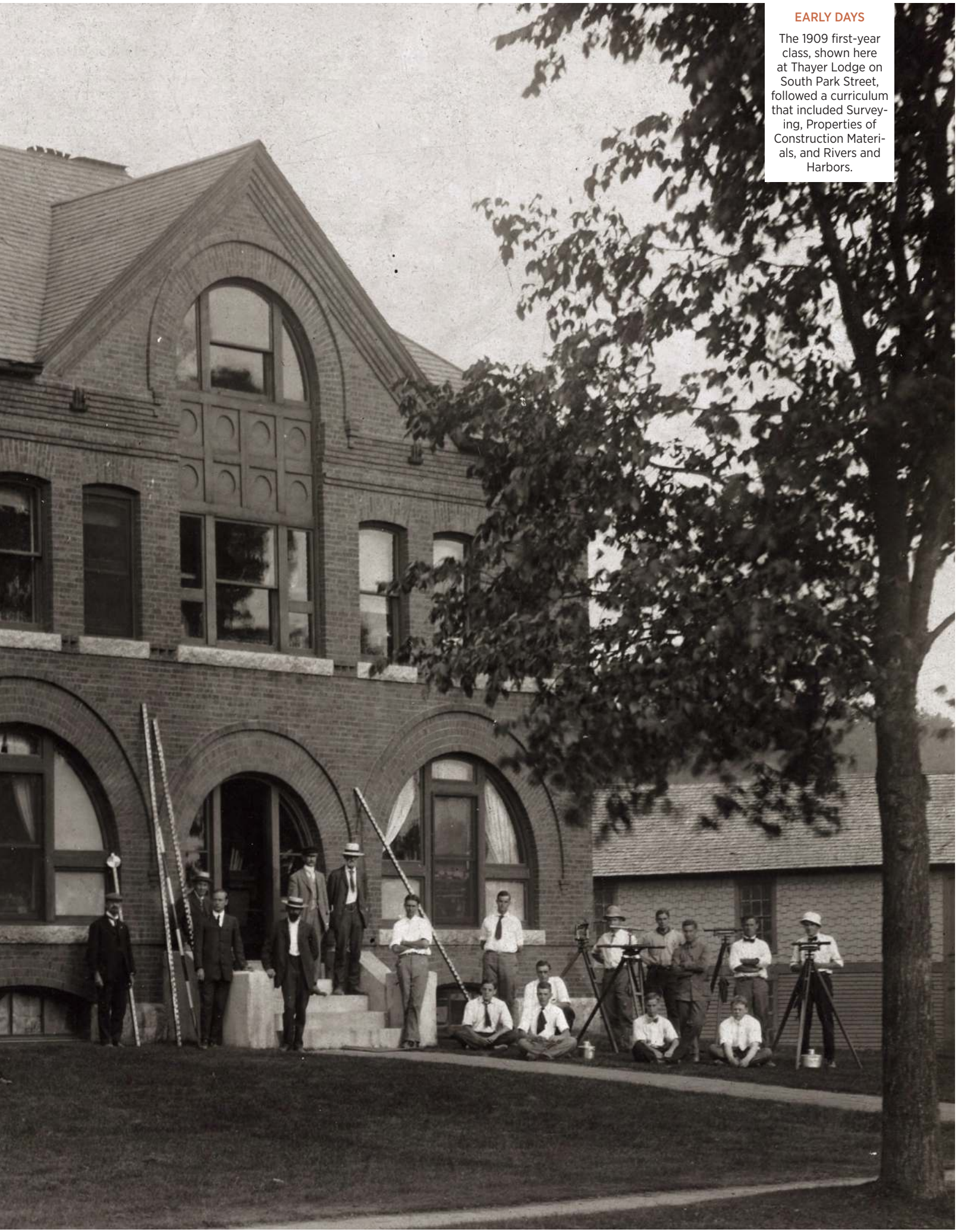
First Look



EARLY DAYS

The 1909 first-year class, shown here at Thayer Lodge on South Park Street, followed a curriculum that included Surveying, Properties of Construction Materials, and Rivers and Harbors.

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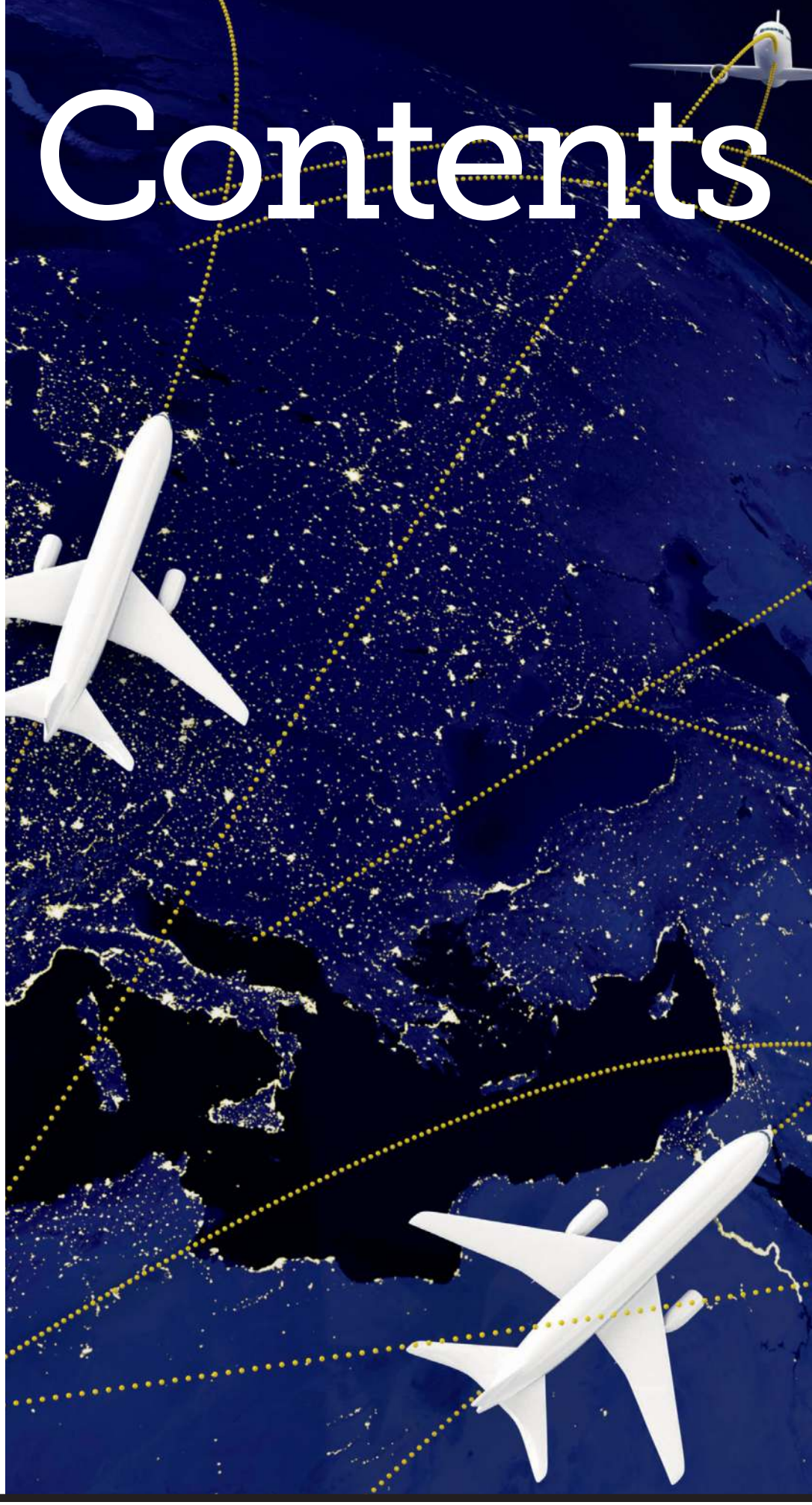

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THE Great Hall

NEWS FROM AROUND THAYER SCHOOL

Q&A

Needle in a Haystack

ON SEPTEMBER 30, 2017, AN AIRBUS A380 TOOK off from Paris headed for Los Angeles. It never arrived. While flying over the Greenland ice sheet, one of its engines failed and a fan hub split, with one part falling from the plane. The crew landed in Canada without further incident, but the part remained on the ice sheet.

The Geological Survey of Denmark and Greenland (GEUS) assembled a search team to locate the missing part to help determine what went wrong. But finding the piece on the ice sheet was like trying to find a needle in a hazardous haystack.

Enter Thayer PhD students Joshua Elliott and Austin Lines. They joined the GEUS team with FrostyBoy, an autonomous, electric-powered vehicle capable of towing ground-penetrating radar across unstable crevasses.

LOST ON ICE?
PhD students Joshua Elliott and Austin Lines traveled to Greenland with a search team to locate a missing piece of an A380 place engine that came apart mid-flight.

Tell us about FrostyBoy.

AUSTIN LINES: We found that the robots previously designed by Dartmouth students were not adequate for the low-cohesion terrain of Greenland. So we decided to rebuild a robot with larger wheels that could handle the loose terrain and had lower surface pressure to navigate the fluffy snow of Greenland. FrostyBoy is a one of a kind.

How did you come up with the name?

LINES: FrostyBoy is actually the name of a soft-serve ice cream machine in McMurdo Station, a U.S. Antarctic research station on the south tip of Ross Island. We like machines named after machines, so we decided to name the robot FrostyBoy.

How did you begin the search?

JOSHUA ELLIOT: We wanted to survey three likely spots, but two of them were in crevasse zones. There had been some overflights with a special radar-equipped airplane, which gave us a general sense of where the crevasses were. The idea was to create a path from safe areas out to the crevasse field. We selected the area and the route and then sent out the robot. Once the robot did the survey, then came the task of looking through all of the data, which is really labor-intensive. Then we handed that off to the mountaineer, who made the call whether to drive over it with a snow machine or go in with rope teams and walk on the ground.

LINES: In the search for crevasses, we detected an anomaly in the ground-penetrating radar data. After multiple surveys, it kept showing up. When we actually found the signal using the metal detector, we were very excited—but we were also in the middle of a crevasse zone. We smiled, snapped a picture, got on the helicopter, and left.

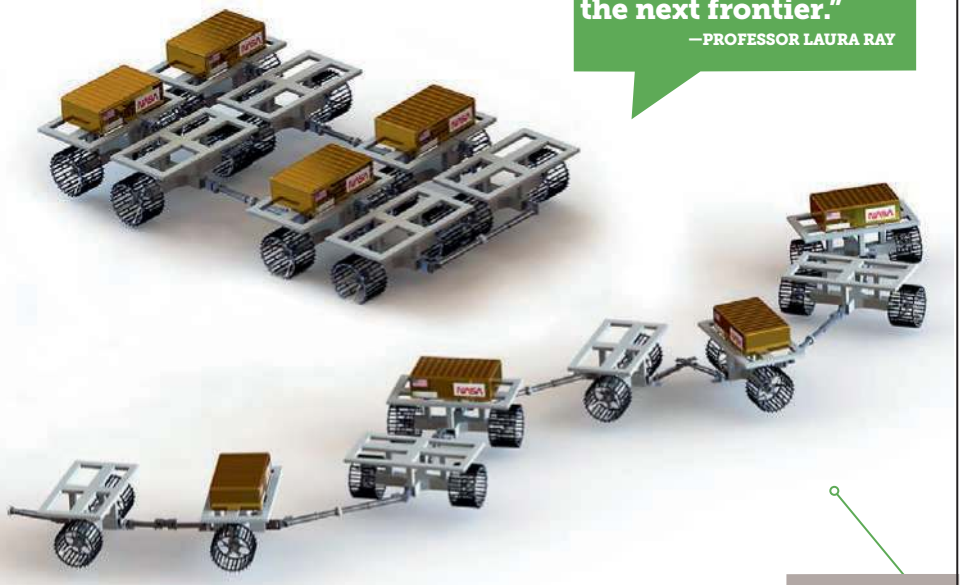
What's the big picture?

LINES: Once they inspected the part, they found there was a crack that had formed due to the metallurgical process of making the fan hub. Now they're requiring all A380s to go through rigorous testing for the flaw. If the same problem is found with the metallurgy, they have to rebuild the whole engine. It costs $750,000 per engine and there are four engines per plane—so it really adds up.

—Julie Bonette

Editor's Note: *Lines and Elliott have been contacted by a team looking for lost WW II planes in Greenland and are eager to start their next expedition.*

"Lunar and planetary exploration is the next frontier."
—PROFESSOR LAURA RAY



SHREWS
Strategic Highly compliant Roving Explorers of other Worlds—focuses on mobility achieved through a class of robots able to latch onto each other to minimize the chance of getting stuck or having to be rescued.

COMPETITION

NASA Challenge

FOR THE SECOND STRAIGHT year, a team of Dartmouth engineering students has been named a finalist in NASA's Breakthrough, Innovative and Game-changing (BIG) Idea Challenge. For this year's competition, NASA sought ideas proposals for Lunar rovers that can successfully explore the permanently shadowed regions in and near the Moon polar regions.

The Dartmouth team's idea—SHREWs: Strategic Highly compliant Roving Explorers of other Worlds—focuses on mobility achieved through a class of robots able to latch on to each other to minimize the chance of getting stuck or having to be rescued. The team took inspiration from the actual mole-like mammals, which latch onto each other's tails to form a train or caravan and move in an orderly fashion.

"Lunar and planetary exploration is the next frontier, so it's pretty exciting," says Laura Ray, professor of engineering and senior associate dean of faculty development at Thayer School. "I think this is almost a once-in-a-career opportunity, but here we are again, so I'm pretty proud of being a finalist two years in a row."

Ray served as faculty advisor to last year's Dartmouth team as well. That group of undergraduates won the 2019 BIG Idea Challenge for their innovative design of a Mars greenhouse that can grow and sustain a crew of astronauts on a future mission to the Red Planet.

Final designs for 2020 will benefit NASA's Artemis program, an effort to return astronauts to the moon in 2024. Funding—provided in part by NASA's Game Changing Development program—will be used on projects to help support a sustained presence on the Moon by 2028.

—Julie Bonette

OPPOSITE PAGE: COURTESY GREENLAND GUIDANCE. THIS PAGE: COURTESY SHREWS TEAM AND MALLORY BYRD.

PERSPECTIVE

Thayer Builds a Better Face Mask

ASSOCIATE PROFESSOR OF ENGINEERING Solomon Diamond and a team of engineers have designed, tested, and assembled high-performance face masks with higher levels of protection than standard cloth masks for service workers who interact with at-risk populations and for members of the community at greater chance of infection.

The development process went through many iterations, based on the concept of incorporating a high-grade filter material into a cloth mask design. Initially Diamond consulted doctors, nurses, and health and safety specialists at Dartmouth-Hitchcock Medical Center, engineering design colleagues at Thayer, and engineers at Hypertherm.

"This project brought together all the core elements of what Thayer School and Dartmouth are all about—addressing a need in society, technical innovation, human-centered design—and deals with taking ideas from concept into practice, addressing the full range of requirements from supply chain management through to production quality control and distribution," says Diamond, whose work at Dartmouth focuses on biomedical imaging.

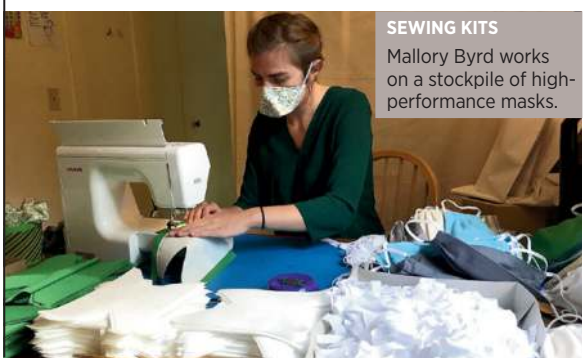
Over time, the team grew from engineers to other faculty and staff, including the Thayer Machine Shop, where Operations Manager Lee Schuette and Technical Instructor Scott Ramsey created laser-cutting profiles and began producing the material components with assistance from the Shop's Gary Hutchins.

A team of 25 Thayer faculty and staff volunteers have organized home sewing kits with detailed assembly procedures and quality control conducted by Thayer researcher Ryan Chapman Th'19.

Mallory Byrd '19 Th'20 stayed on campus to assist with assembling and distribution.

"For me, it feels like this is a time to be constantly thinking about how you can help. And what's kept me going is that there are all of these people at Thayer who are so willing and so engaged with this project," Byrd says. "It's so emblematic of the spirit of Thayer engineering that professors and the staff are always thinking of how to employ engineering for the benefit of others."

—Bill Platt



SEWING KITS
Mallory Byrd works on a stockpile of high-performance masks.

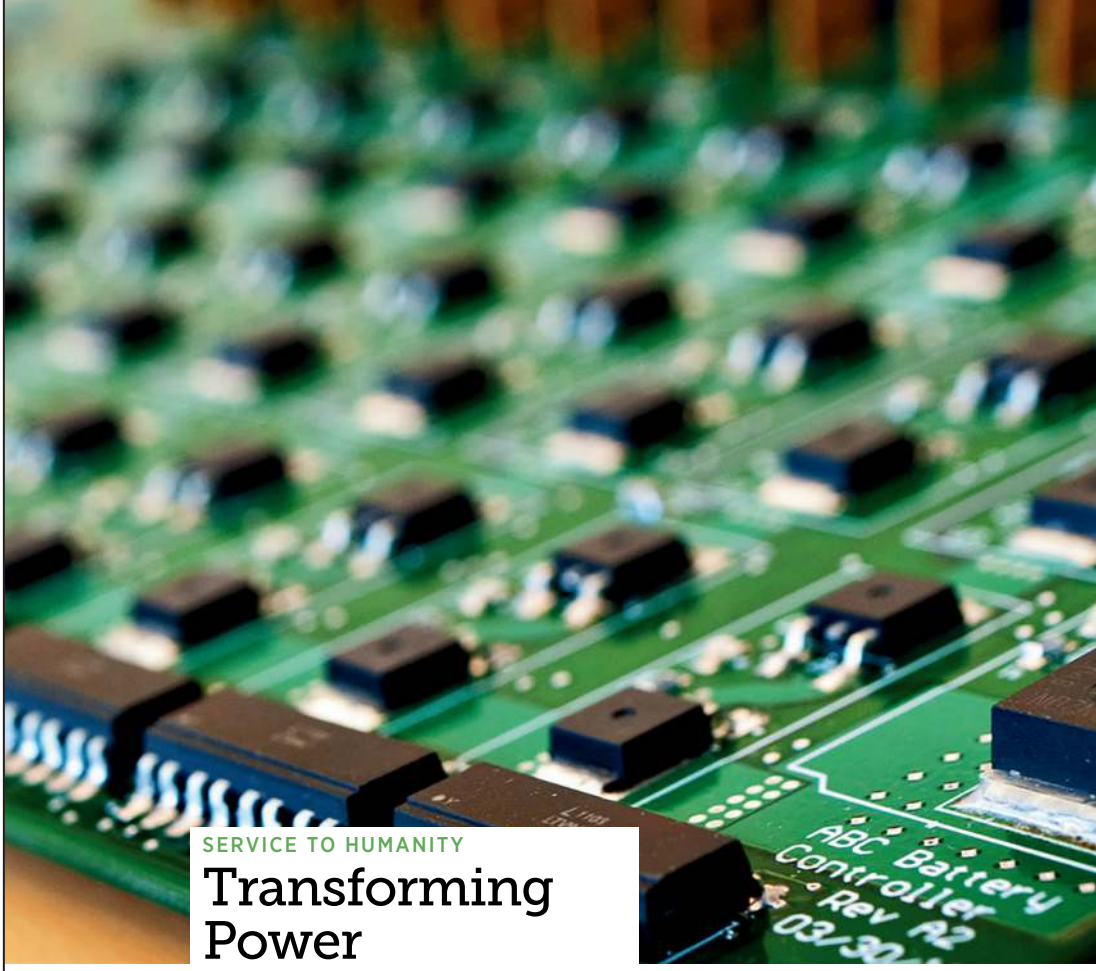
WELCOME

Yan Li

LI JOINED THE THAYER FACULTY in January as an assistant professor of engineering. Her research focuses on the mechanics of advanced materials, and involves multiscale, multi-physics modeling. Li taps integrated computational and experimental approaches to develop next-generation material design.

"I believe curiosity drives innovation," says Li, who earned her PhD at the Georgia Institute of Technology and her MA at Shanghai Jiao Tong University. "I like my students to think outside the box and be creative about problem-solving." Li previously collaborated with Boeing, Gulfstream, and GE, and her research has been supported by the U.S. Army Research Laboratory, Sandia National Laboratories, and the National Science Foundation's Center for Computational Materials Design.

TRANSPORTED
Hands-on, project-based engineering is not new to Thayer School students. Every term, Intro to Engineering students are given a problem to solve. This year the focus of the course was "Improving the Quality of Life in Winter." In response, one student team designed Turtle Delivery—a safe and efficient way to transport large sea turtles to warmer waters via airplane.



SERVICE TO HUMANITY

Transforming Power

DARTMOUTH IS PARTNERING WITH four leading electrical tech companies to form the first National Science Foundation-funded industry-university collaborative research center focused on integrated power management and delivery.

The new Power Management Integration Center (PMIC) will provide GE Research, Analog Devices, Empower Semiconductor, and Ampt with access to Dartmouth's R&D expertise, facilities, and intellectual property. The output: opportunity to address a range of challenges facing next-generation power electronics.

"Power is in almost everything," says Jason Stauth, Thayer professor and PMIC codirector. "We want to remove technology bottlenecks and help make electronics smaller, more efficient, and cheaper for both industry and consumers."

Microelectronics and integrated circuits have revolutionized computing, communications, and information technology. However, power management hardware remains a key obstacle to further reducing systems' size and cost in virtually all applications, from mobile communications and internet-of-things devices to electrified systems in automobiles and aircraft.

"We want to remove technology bottlenecks ."
—PROFESSOR JASON STAUTH

Focusing on integrated power management circuits and systems on a chip, PMIC aims to achieve extreme power density and efficiency with the potential to transform transportation, communication, and energy generation and consumption. These innovations have a range of applications, such as enhanced battery life for mobile platforms or solar and electrochemical energy storage as well as potential cuts to overall costs and carbon emissions.

"Companies want to create products that use less energy without increasing cost," says Professor Charles Sullivan, a PMIC codirector. "Researchers here are exploring and developing the technology to help them do that. PMIC will bring Dartmouth researchers and companies together."

Member companies will share in both the cost and benefit of cutting-edge R&D and gain a higher return on investment. Membership also comes with up to 12 votes on PMIC's industry advisory board, which steers the center and provides input into plans for expansion.

—Catha Mayor Lamm

Kudos

Green Returns

In an effort to improve upon an existing green initiative—and clear out "science experiments" growing in dorm rooms—a student team has developed a return system for Dartmouth Dining Service's (DDS) Green2Go reusable food containers. "We're students and so we've gotten these containers of food and then had them sit in our dorm rooms for a week or two," says **Sebastian Logue '22**. "Over time they grow nasty things." That contamination has also meant DDS has had to discard the containers, which are not biodegradable or recyclable. "It defeats the sustainability aspect of the whole system," he says. Logue, **Christopher Connors '21**, **Seamus Hall '20**, **Jenna Lee '22**, and **Maxwell Holden '22** won the Phillip R. Jackson Award for their solution. The team modified an existing trash can with a scanner to read a food container's bar code, credit the student's account, and then unlock the unit. Each day DDS can collect the used containers, reset the scanner, and prepare for the next meal. The team hopes to roll out 20 autonomous cans across campus to augment the three return points currently at the dining halls. "It's good for people to see that students care," says Logue, "and that we're trying to improve upon what exists already."

OPPOSITE PAGE, LEFT: KATHRYN LAPIERRE. OPPOSITE PAGE, RIGHT: NATIONAL SCIENCE FOUNDATION. THIS PAGE: KATHRYN LAPIERRE.

ELECTED **Professors Laura Ray and Stuart Trembly** have been named senior members of the National Academy of Inventors for producing technologies that impact society's welfare.

NAMED **Jennifer Lai Th'20**, a recent PhD graduate, has been named 2020 Schmidt Science Fellow along with just 21 other early-career scientists from around the world. Lai, a protein engineer who designs vaccines, will shift her research focus to high-throughput analysis of antibody repertoire data. .

HONORED **Professor Geoffrey Parker**, director of Dartmouth's MEM program, won the Thinkers50 Digital Thinking Award. He was recognized for his analysis of the concept of the inverted firm—in which value is increasingly created outside rather than inside a firm.

PUBLISHED PhD graduate **Irwin Tendler Th'20** is part of a Dartmouth team that found evidence to support the common phenomenon of seeing flashes of light during brain radiotherapy. Their research was published in the *International Journal of Radiation Oncology, Biology, & Physics*.

AWARDED Biomedical engineering major **Delia Friel '20** has earned a full scholarship to pursue a master's in global affairs at the Schwarzman College at Tsinghua University in Beijing, China.

WON Her ability to teach beginning coders online has earned **Professor Petra Bonfert-Taylor** the 2019 edX Prize for Exceptional Contributions in Online Teaching and Learning.

SELECTED The Society for Industrial and Applied Mathematics has recognized **Professor George Cybenko** as a 2020 SIAM fellow for his contributions to theory and algorithms in signal processing, artificial neural networks, and distributed computing systems.

HONORED The Optical Society and the Society for Imaging Science and Technology have awarded **Professor Eric Fossum** the 2020 Edwin H. Land Medal for his "groundbreaking contribution to digital imaging technology."

AWARDED **Professor Jifeng Liu** is a principal investigator on a team receiving a U.S. Department of Defense grant to develop infrared imaging sensors that could significantly improve night-vision systems for self-driving vehicles.

I Want One of Those!

STUDENT PROJECTS

SOLO: SOME (CUPS) ONLY LIVE ONCE

A team of undergrads identified a problem with the way students use and dispose of plastic cups. Even when cups end up in a recycling receptacle, a single cup holding even a small amount of fluid can contaminate the entire collection—making it ineligible for recycling. The group's answer: an automatic cup washer to prevent that contamination. "We devised a system that would wash and sanitize the cups so that we can use them again or recycle them," says Sudharsan Balasubramani '22. Their invention features a multistep cleaning process: a top and bottom water spray, a hydrogen peroxide mist, a chamber where the cup sits for 40 seconds to ensure bacteria is killed off, and a final water rinse. "The most rewarding aspect of this was looking for something that didn't exactly work and then being able to fix it as a team," he says. He and Kimberly Tan '22, Liam Kirkpatrick '22, James Fleming '22, and Vlado Vojdanovski '22 won the winter term Phillip R. Jackson Award for best overall performance in ENGS 21: Introduction to Engineering. Their teaching assistant was Shannon Ropp '19 Th'20.

—Kathryn Lapierre

MILESTONES

Three Innovators Retire

JOHN COLLIER

ALEXANDER HARTOV

MICHAEL MAYOR

JOHN P. COLLIER '72 TH'73 TH'75 TH'77, the "father" of Thayer's signature ENGS 21: Introduction to Engineering course and a beloved faculty for more than 40 years, retired in June. Collier joined the engineering faculty in 1979 and has been pivotal in transforming Thayer's approach to education and research. A design engineer whose work also focused on biomechanics and biomedical materials, Collier cofounded the Orthopedic Device Retrieval Program at Dartmouth Biomedical Engineering Center (DBEC) with orthopedic surgeon, Dr. Michael Mayor. There he grew and oversaw one of the largest collection of retrieved joint implants in the world—now more than 15,000—and helped identify and solve problems related to the production, design, and materials of joint replacement technology. Throughout his career he has won numerous accolades, including NH Professor of the Year in 2010, and one of the National Academy of Engineering's highest honors—the Bernard M. Gordon Prize for Innovation in Engineering and Technology Education.

ALEXANDER HARTOV TH'88 TH'91, who combined his biomedical imaging and instrumentation research with a dedication to student mentoring and teaching, will retire in June. Hartov joined the faculty in 1996 and has taught courses in instrumentation and measurement, electrical network theory, and digital image processing. He also served as director of Thayer's MS and PhD programs. Hartov's work focused on imaging for breast cancer and prostate cancer screening, image-guided and fluorescence-guided neurosurgery, and automated segmentation. For more than a decade, he also served as a lead investigator in numerous projects for the Brain Research Group at Dartmouth, a multidisciplinary group of faculty, physicians, and researchers from Thayer, Geisel School of Medicine, and DHMC that develops neurosurgery technologies. With Dartmouth Jewish Studies Professor Lewis Glinert, Hartov also helped launch the Dartmouth Jewish Sound Archive, one of the world's leading online archives of Jewish recordings, in 2002.

MICHAEL B. MAYOR, cofounder of the Orthopedic Device Retrieval Program at Dartmouth Biomedical Engineering Center (DBEC), retired in January. Mayor, an adjunct professor of engineering and emeritus professor of orthopedics surgery at Geisel School of Medicine and DHMC, was a pioneer of the total hip replacement in the US. In 1971, when he realized there was no central resource for evaluating orthopedic implant performance, he partnered with Professor John Collier to develop a center for retrieval analysis. DBEC's program—which studies orthopedic devices and provides feedback to manufacturers and surgeons—is now one of the largest in the world. His research has facilitated the optimization of design and materials leading to profound quality-of-life improvements for patients worldwide. In addition to his work at DBEC, Mayor has guided engineering students for more than 30 years, serving on the thesis committees for bachelor's, master's, and doctoral students at Thayer.

LAB REPORT

Clearer Imaging

A TEAM OF RESEARCHERS SPEARHEADED by Dartmouth engineers is trying to minimize unnecessary breast biopsies, as most people who undergo biopsies do not have cancer. Their proposed technique combines two commonly used methods and may streamline the diagnostic process by providing substantially clearer imaging—and more accurate diagnoses—for doctors.

The Academic-Industry Partnership (AIP) recently received a $3-million grant from the National Cancer Institute to pursue the development of a multi-modal breast imaging platform that simultaneously uses microwave *and* magnetic resonance imaging, a first in the field.

> **"The idea is to combine the two methods to get a more accurate rendering of the tumor."**
> —PROFESSOR PAUL MEANEY

"An MRI by itself produces very high-resolution images, but weak specificity, meaning it's hard to determine if a suspicious area is malignant," says Professor Paul Meaney Th'95, a multi-principal investigator (PI). "Microwave imaging provides images with remarkable specificity, but suffers from poor resolution. The idea is to combine the two methods to get a more accurate rendering of the tumor or lesion zone, but it's very difficult to do."

The approach could also eliminate the need for gadolinium, a contrast agent commonly used in MRIs that has come under scrutiny by the FDA for remaining in patients' bodies, including their brains, sometimes for years.

The Dartmouth team includes Keith Paulsen Th'84 Th'86, the Robert A. Pritzker Professor of Biomedical Engineering, and experts at Dartmouth-Hitchcock Medical Center. It has already performed successful experiments for proof of concept and plans to improve prototypes and complete clinical trials during the five-year grant period.

—Julie Bonette

RESEARCH

A Resilient Robotic Bug

TODAY'S ROBOTS CAN BE INTELLIGENT AND TOUGH AND ARE already helpful to humans in many ways. There remain a lot of scenarios, however, where traditional robots cannot function well. For example, robots often are made of rigid materials, such as alloys and plastics, which makes them vulnerable to fracture and their motility becomes limited in confined spaces or on rough terrains.

To solve this problem, a group of researchers at Dartmouth developed a miniature robotic bug that has a flexible body, is easily maneuverable, can crawl on different terrains and through narrow spaces, and can be completely flattened without damaging its functionality.

These unique capabilities are achieved through a combination of innovative design and cutting-edge transducer materials. The robot is built using thin polyimide films that can be actuated by electrostatic force, which is ubiquitous in our daily life. The actuator, which makes up the body of the robot, has a three-layer sandwich structure with the top layer buckled up to form an arch shape. By supplying an AC voltage to the top and bottom films, the buckled top film will deform periodically, thus converting electrostatic potential to kinetic and elastic energy.

"Due to its thin-film-based designs for both buckled light-weight structure as well as powerful actuation, the robotic bug is flexible enough to crawl through narrow spaces, quickly maneuver through various landscapes and resilient enough to recover after being crushed," says Congran "Billy" Jin, an engineering PhD candidate at Dartmouth and first author on the paper.

"The robot is also highly tunable through some 'special' design modifications," says Zi Chen, assistant professor of engineering at the Thayer School of Engineering. "For instance, we added bi-stable, origami-inspired legs so that it can move either both forward or backward when the legs switch between the two mechanically stable states."

This unique robotic bug may pave the way toward a variety of potential applications in such areas as detection/inspection, search-and-rescue, and disaster relief.

—Zi Chen and Congran Jin

This article originally appeared in Advanced Science News *and is reprinted with permission.*

THINKING IN SYSTEMS

WHY PUBLIC POLICY NEEDS DARTMOUTH ENGINEERS

BY KRISTEN SENZ

"There are no separate systems. The world is a continuum. Where to draw a boundary around a system depends on the purpose of the discussion."

—DONELLA H. MEADOWS*

Browsing the daily news headlines might lead one to conclude that we live in an era ruled by populism, fear, and misinformation. In reality, over the past 20 years, officials at all levels of government have increasingly sought data and technical expertise to evaluate and enact effective public policy. This shift is part of a constellation of factors that has set the stage for engineers to take a more active role in public discourse and policy.

Such factors include record levels of public trust in engineers as professionals, greater support for interdisciplinary research, and a broadening of traditional systems engineering to include the policy landscape. In addition, both private and public sectors have increasingly recognized the value of the systems approach to solve complex problems of the modern world—from climate change, to energy, to pandemics.

*DONELLA H. MEADOWS WAS AN AMERICAN ENVIRONMENTAL SCIENTIST AND WRITER WHO TAUGHT AT DARTMOUTH FROM 1972 UNTIL HER DEATH IN 2001. SHE IS BEST KNOWN AS THE LEAD AUTHOR OF THE INFLUENTIAL BOOKS, *THE LIMITS TO GROWTH* AND *THINKING IN SYSTEMS: A PRIMER*.

ILLUSTRATION BY MIKE ELLIS

BEYOND NUTS AND BOLTS

Over the last two decades, the progression of Dartmouth engineering professor Mary Albert's career as a climate researcher has mirrored the evolution of the field of systems engineering as a whole. For years she studied the microstructures of snow and ice, taking dozens of research trips to Summit Camp on the Greenland ice sheet. She later became involved in the ice core research community that has revealed both the speed and intensity of climate change.

"From the ice core record, we know that the CO2 in the atmosphere now is higher than it has been in at least 800,000 years," she says. "But we also know that climate can change completely in less than ten years. A decade ago, scientists thought climate was a slow-moving animal that could only change over millions of years."

A public presentation of her research findings in Greenland led a group of native Greenlanders to approach Albert for help as they grapple with the realities of climate change in Qaanaaq, an Arctic hunting and fishing community in northern Greenland. Albert partnered with them to form a team of scientists, residents, students, and policymakers and proposed to the National Science Foundation a collaborative, systems-based approach to fortifying a community against an uncertain future.

Recently, the NSF awarded the team $2.6 million to spend the next four years plotting a course to sustainability and a transition to renewable energy that works in concert with local culture and values, against the backdrop of a melting ice sheet and rising sea level.

"Having an engineering background helps me to solve problems that I haven't seen before and that are under constraints of various kinds, and that's especially true with engineering and climate change today," Albert says. "The environment of the future is different than the environment of the past due to the changes that we are encountering, so we need new approaches that also account for predictions of future conditions."

The goal of the Qaanaaq project is to collaboratively design a system of simple, cost-effective innovations and adaptations that can operate effectively within the context of the local environment, Albert explains. That requires going beyond the nuts and bolts of physical engineering; it represents a more holistic understanding of systems engineering as a discipline.

"It's not just combining an electrical system and a mechanical system in a car," she says. "The system now, conceptually, is not only the built environment and the natural environment, but also the cultural values and the finances and the policy. All of those are elements in the system."

"This is the dawn of a new era in engineering."
—PROFESSOR MARY ALBERT

Fortuitously, these efforts are occurring at a time when a nascent Greenlandic government, working toward independence from Denmark, seeks to build a new body of public policy based on research and data. Local officials are hungry for evidence they can take to Nuuk, Greenland's capital, to advocate for policies that fit with the values and conditions in Northern Greenland, which faces different challenges than the south.

Albert sees the project in Greenland as a culmination of years of scientific study and a chance to not only improve lives, but also create a template for collaboratively addressing the effects of climate change.

"This is the dawn of a new era in engineering," she says. "Climate change is going to get much worse before it stabilizes. It needs all hands on deck, and it's not just the microlayer on a single solar panel. That kind of innovation is needed, but there's also a huge need for innovation that involves the whole-systems approach, including policy, economic, and engineering aspects."

A NEW KIND OF POLAR EXPEDITION

In his work as a geophysicist and Arctic sea ice expert, Thayer professor Don Perovich has spent much of the last decade focused on interdisciplinary research. He is currently participating in the largest polar expedition in history, a floating observatory called MOSAiC (Multidisciplinary Drifting Observatory for the Study of Arctic Climate) that involves 20 countries and hundreds of scientists.

The endeavor centers on the yearlong journey of a German research vessel that set off from Norway in September 2019 to drift through the Arctic, capturing the most comprehensive data on the sea ice cover to date. These data can be used not only to predict future trends in sea ice change, but also to develop responses to challenges facing Arctic communities today.

"We will really get to see the whole evolution of the ice cover," says Perovich, who serves as co-lead of MOSAiC's sea ice team. "It's as if we finally get to read the entire book, instead of just a chapter here and a chapter there."

As the sea ice cover forms later and later in the fall, it exposes coastal communities to more autumn storms that cause coastal erosion. As the ice retreats, it makes undiscovered oil reserves more accessible, with serious global geopolitical implications. Similarly, the opening of the Northwest Passage creates economic opportunities in tourism and shipping that ripple across the world. To understand and respond effectively to these changes, policymakers need reliable information and analysis.

"We want to be able to take those observations and that understanding and develop ways to respond to the ongoing changes, which in the Arctic is really important, because the research that we do up there is more than an intellectual exercise; the changes in the sea ice cover are impacting people today."

The far-reaching applications and legacy of the MOSAiC mission excite Perovich, who over the course of forty years of study has spent nearly three years in the Arctic. Over the last 20 years, along with a dramatic change in the Arctic landscape and climate, he has watched the research become increasingly interdisciplinary.

"The Arctic is a system with many components," he says, "and to understand what's going on, you can't just study one of those, you have to study all of them in concert, and that's really been something that has been developing over the last couple of decades. Now, we're starting to take it one step further—we've got to take this knowledge of the physical system and the ecosystem and tie that with human dimensions."

Success in this work, he says, depends on openness to collaboration and clear communi-

"We've got to take this knowledge of the physical system and the ecosystem and tie that to human dimensions."
—PROFESSOR DON PEROVICH

cation. The latter can prove especially challenging for those accustomed to narrow specialization.

"It's easy to stay focused on your one component of the system, but I think the societal problems we have really require cooperation by different groups," he says. "At first, it can be kind of awkward, and this relates to jargon—you say something that only makes sense to you and your friend—but once you get past that, it's really exciting."

As MOSAiC exemplifies, translating and transferring knowledge across disciplines broadens everyone's understanding of the system, giving engineers in particular important insights that enable them to design more powerful solutions. Perovich says it's imperative that engineers' perspectives are part of policy debates, whether that means they run for office, act as policy advisors, or find other ways to contribute input to lawmakers.

THE ENGINEER IN THE ROOM

A new Gallup poll puts Americans' level of trust in members of Congress slightly above that of car salespeople, an improvement over last year, when members of the House of Representatives were the least-trusted of all professionals. In contrast, respondents rated engineers second in terms of honesty and ethical standards, behind only nurses and ahead of medical doctors.

Officially, only 11 of the 535 members of the 116th United States Congress are engineers by training. Rep. Sean Casten (D-Ill.) Th'98 is one of them. He sits on the House Science, Space and Technology Committee (and its environment and energy subcommittees) and the House Select Committee on the Climate Crisis.

A clean energy entrepreneur prior to his election in 2018, Casten's understanding of the issues is grounded in the quantitative. He often finds himself explaining exponential growth—in carbon dioxide concentration, or the spread of viral infections, for example—to colleagues who are less adept at geometric sequencing. When decision-makers fail to grasp orders of magnitude, he says, "everything you do will be too little, too late."

Because of his deep knowledge in the renewable energy space, Casten often brings a reality check to debates about the future of various technologies.

"There are the things that people want to be true about our energy system, and then there are the things that are true when you constrain them by the first two laws of thermodynamics," he says. "For most of my colleagues, who are not trained as engineers, they don't necessarily understand where those constraints are."

In debates about carbon capture and sequestration technology, for example, Casten sliced through rhetoric about saving coal-industry jobs and predicted the demise of FutureGen, a now-defunct plant in downstate Illinois that cost the federal government $1 billion.

"Engineering has enough humility to it that you don't assume that you, individually, can build the whole machine."

—REP. SEAN CASTEN TH'98

"I have enjoyed, in those conversations, being the person who says, I'm going to take a napkin and explain to you why carbon capture and sequestration is never, ever going to save the coal industry," he says. "It's the only technology out there that raises the capital cost of power generation and increases the operating cost… On those big comprehensive bills, sometimes it's kind of fun to be the engineer in the room."

Casten's occupational orientation also shapes his overall approach to the job. Asked how he handles the politics of lawmaking, he says: "This is a political job, so you've got to deal with that as an input to the system and try to manage it, but it's just an input. It's like gas in a car."

Like Albert, Perovich, and many other engineers, Casten views the world as a series of interconnected systems, with various feedback loops producing or detracting from desired functions. Looking through this lens, these engineers can zero in on bottlenecks and find ways to address them using the tools available to them—whether that's through their own scientific specialty or by reaching out to others with the knowledge and skills to affect change at the policy level.

"I think engineering at its best has enough humility to it that you don't assume that you, individually, can build the whole machine," Casten says. "You can have an appreciation for what the machine does, how it works, and make sure you've got all the moving pieces in place to get something done."

KRISTEN SENZ is a freelance writer based in Bloomington, Indiana.

GAINING THE DEPTH AND BREADTH TO LEAD

Thayer's combined major in engineering and public policy

As technology gets embedded into nearly every facet of society, studying the intersections of engineering and public policy has become critical for the next generation of leaders.

That's why Thayer School in 2008 introduced a modified major in engineering and public policy in partnership with the Nelson A. Rockefeller Center for Public Policy. At the time, Thayer's then-dean Joseph Helble said the modified major "puts engineering on an equal footing with the liberal arts," enhancing the breadth of students' knowledge and preparing them to contribute much-needed technical expertise to public discourse.

The major combines the technical aspects of engineering with additional areas essential for policymaking, including economics, ethics, and policy analysis. The modified major is intended both for engineers who want to influence public policy, and policymakers interested in gaining a working understanding of technology.

Since 2011, 11 students have graduated with the modified major, leveraging it to explore how various engineered solutions fit into the daily lives of the people they are intended to serve. They also gained the skills to inform public debate and shape public policy.

Laura Kier '12 used the modified major to pursue her interest in sustainable design. "My take on my major is that I will be able to survey human needs, understand environmental policy, and engineer solutions to our increasingly unsustainable world," she said.

Now Dartmouth's Provost, Helble, who spent a year in Washington as a science advisor in Senator Joe Lieberman's office, is a strong proponent of science communication and the involvement of engineers in public life.

"All of us with technical backgrounds should do our part to shape the decisions we entrust to Congress," he once wrote. "Our collective future depends on it."

FLYING IN THE FACE OF DANGER

KEJI WEI TH'19 IS RE-DESIGNING THE TECHNOLOGY OF AIRLINE TRAVEL

BY JULIE BONETTE

KEJI WEI SPENDS EVERY WORKING DAY THINKING ABOUT DISASTERS.

Unexpected catastrophes such as typhoons and earthquakes wreak havoc on lives, including plans to visit loved ones, sightsee in a foreign land, or just try to get back home. It's Wei's job to plan around and overcome these obstacles to get people to where they need to go.

Wei works as a senior operations research analyst at Sabre Corp., a leading technology solutions provider to the travel industry, and is stationed at the company's global headquarters in Southlake, Texas, outside of Dallas. At Sabre, Wei acts as an airline consultant by using available data and mathematical models to provide real-time solutions to customers whose travel has been disrupted for any number of reasons.

"I design disrupted passengers' itineraries for airlines all over the world," says Wei. "For each airline, my job is to design a model and its corresponding solution approach for the purposes of assigning the optimal flight to each disrupted passenger."

So, the next time your flight is successfully rebooked after a volcano eruption or tornado spoils your initial ride, you might want to thank Wei.

Wei is responsible for generating parameters for every imaginable travel scenario. He has to consider the numbers of available aircrafts and disrupted passengers when trying to find a solution that works for everyone—passengers and airlines—and then he analyzes and answers questions that may arise.

Wei also utilizes operations research to minimize the ripple effect of one delay on subsequent flights, a phenomenon known as delay propagation, through smart-planning of crew itineraries. Wei says his biggest daily motivation is to help airlines save millions of dollars—costs then passed on to consumers—by optimizing their own itineraries using mathematical models.

"My hope is to improve airline efficiency and make travel smart by using my mathematical knowledge," he says.

The prestigious Mathematical Contest in Modeling initially sparked Wei's interest in the airline industry. He first competed in the international challenge when he was 19 years old, and just a few years later he was named a meritorious winner of the multi-day competition.

"I was attracted to the airline industry because I wanted to design mathematical models and solution approaches to solve practical problems in the real world," says Wei.

A year later, in 2011, Wei received his BE from Xi'an Jiaotong University in his native country of China, along with its Best Undergraduate Thesis Award. After spending some time as a project officer at Nanyang Technological University in Singapore, where he focused on energy-efficient, rail-guided vehicle routing, he landed at Thayer in the fall of 2014.

Wei became the first Dartmouth PhD advisee of Professor Vikrant Vaze. In fact, Wei applied to Thayer before Vaze was officially a member of the full-time faculty.

"My first read of Vaze was that he is very serious," says Wei. "After that, we had a good time. He will always be a friend of mine."

"We connected over Skype and discussed each other's research interests," says Vaze about his initial connections with Wei. "From the beginning, Keji came across as someone who is truly passionate about research and enthusiastic and open to trying out and evaluating new ideas."

Once they were both at Thayer, Wei worked with Vaze on five major transportation-related research efforts:

- Quantifying and analyzing the ripple effect a delayed flight has on subsequent flights due to the scheduling of crew itineraries;
- Optimizing airline timetables and fleet assignments by incorporating passenger choice, such as preferred departure times;
- Conducting simulation analysis comparing point-of-care testing and central laboratory testing;
- Solving large-scale crew scheduling problems; and
- Optimizing transit schedules by considering traffic congestion, passenger choice, and ride-hailing services such as Uber and Lyft.

"Over a five-year period, I feel as if Keji and I had a seemingly infinite number of meetings, brainstorming sessions, agreements, disagreements, bottlenecks, discoveries, failures, and triumphs, the pace of which seemed relentless," says Vaze. "I was often impressed by Keji's hard work and his attention to detail, especially when it came to solving really hard, large-scale optimization problems."

Their partnership took flight, earning them accolades amid a flurry of peer-reviewed academic papers that were jointly written. The pair often worked with Alexandre Jacquillat, an assistant professor of operations research and statistics at the MIT Sloan School of Management; Jacquillat later became one of Wei's thesis coadvisors.

"It was fun and challenging," says Wei. "I have a lot of really sweet memories of being supervised by them."

In 2019, while Wei was wrapping up his PhD research at Thayer, he received the Anna Valicek Award at the Airline Group of the International Federation of Operational Research Societies (AGIFORS) symposium. Wei earned the honor with his paper, "Airline Timetable Development and Fleet Assignment Incorporating Passenger Choice," which he coauthored with Vaze and Jacquillat.

"The most amazing thing is that this was

"NOBODY HAS EVER BEFORE TRIED TO COMPLETELY REDESIGN AN AIRLINE'S FLIGHT SCHEDULE FROM SCRATCH TO TAKE PASSENGER PREFERENCE INTO ACCOUNT."

—PROFESSOR VIKRANT VAZE

Keji's second Anna Valicek medal," says Vaze. "He won a runner-up medal two years prior for a different paper we coauthored."

At the same time that Wei received his medal, Vaze and Jacquillat were awarded the Transportation Science and Logistics Outstanding Paper Award in Air Transportation at the Institute for Operations Research and the Management Sciences annual meeting. Vaze's work has also been honored with best paper awards from AGIFORS in 2010, 2017, and 2019 and from the Federal Aviation Administration (FAA) and Eurocontrol in 2011 and 2017. He is the recipient of a number of academic and industry honors, including the National Science Foundation's Faculty Early Career Development Program Award and awards from the U.S. Department of Defense, FAA, National Institutes of Health, and World Wildlife Fund.

Most recently, Wei was the first author on a paper with Vaze and Jacquillat that presented an original approach that could benefit the airline industry with profitable improvements and passengers with preferable travel timetables.

"Beyond ticket prices, perhaps the biggest thing that air passengers care about is the convenience of flight schedule. Yet, due to the associated computational complexities, nobody has ever before really tried to completely redesign an airline's flight schedule from scratch to take passenger preference into account," says Vaze.

In recognition of his achievements, Vaze was named the Stata Family Career Development Assistant Professor of Engineering, a title bestowed upon him this spring by the Dartmouth Board of Trustees. The endowment supports a member of the Thayer School faculty by creating a career development fellowship to leverage growth in teaching, research, or scholarship.

"I felt really humbled to receive that honor, especially since it is named after a family of such inspirational technology innovators and entrepreneurs," says Vaze.

Meanwhile, after earning his PhD in operations research from Thayer late last year, Wei has settled into life after academia—though he hasn't forgotten it. Wei says he hopes to fill the gap between academia and the transportation industry by implementing cutting-edge research and relying on his engineering education.

"Thayer is definitely a magical place for you to explore your research idea, and the school will help build you up not only as an independent researcher, but also as a better person," says Wei. "The most impressive part of Thayer is that students have unlimited chances to interact with other students of totally different backgrounds who are all so talented. I learned how to communicate and share with others, and that type of interactive environment is rarely achieved in any other school in the world."

When asked what advice he would give to current and prospective Thayer students, Wei says: "Jump out of your comfort zone and be independent, confident, and persistent."

Just don't fly by the seat of your pants.

JULIE BONETTE is a contributing editor to *Dartmouth Engineer*.

FLYING IN THE ERA OF COVID-19

These transportation experts share thoughts on how the pandemic may affect the airline industry in the long term.

"One of the hardest-hit industries has been the travel industry and the airlines, in particular. Once this crisis is over, there might be an opportunity to press a complete reset button, for travelers to rethink behavior, and for the industry to reconfigure its service offerings—ideally for the better and towards a greener, kinder, more equitable and more resilient planet."

—Professor Vikrant Vaze

"The airlines have severely cut their operations as a response, but the crisis will end at some point. Passenger transportation systems are integral to our lives and an important pillar of the global economy, so I predict the airline industry will build back up even better than in was before."

— Keji Wei Th'19

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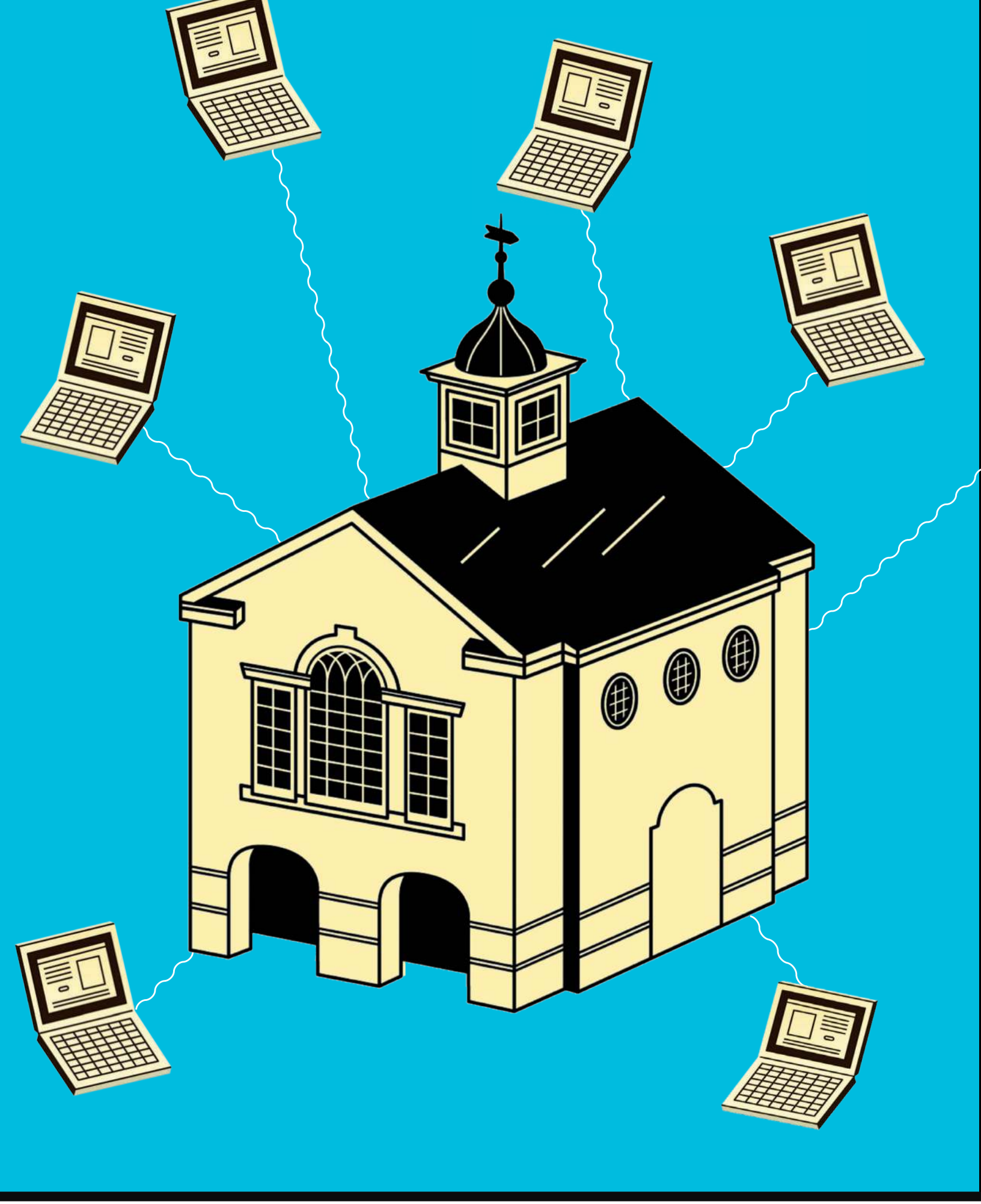


CAMPUS IN THE TIME OF COVID

THAYER SCHOOL ADAPTS TO REMOTE LEARNING.

Thayer School's motto—"To prepare the most capable and faithful, for the most responsible positions and the most difficult service"—has recently taken on new meaning. With Dartmouth's rapid transition to remote learning amid a global health crisis, students and researchers are working hard to prove themselves capable, even as they run 3-D printers from childhood bedrooms, conduct research at kitchen sinks, and attend office hours over Zoom. This time of difficult service has also tested faculty and staff. Providing hands-on, project-based learning and opportunities for innovation within a close-knit community—the hallmarks of a Dartmouth engineering education—is not easy when classrooms and labs are closed and access to campus is limited. Despite these challenges, faculty have found ways to adapt teaching strategies, rethink projects, and secure lab materials and components for kits that can be shipped to wherever students now consider their "classrooms." In some labs, research focus shifted to better understanding the human response to COVID-19. Here are some stories and anecdotes from faculty and staff that speak to the challenges and triumphs in unprecedented times.

BY KATHRYN LAPIERRE

The race to go online was a deep challenge for ENGS 146 [Computer-Aided Mechanical Engineering Design], where students typically spend the majority of their learning time either at Thayer's CAD workstations collaborating side-by-side or operating industrial CNC milling machines in the Mshop [Machine Shop]. We redeveloped the course to enable the students to thrive and learn in what we hope will be the best ENGS 146 offering ever. For the culminating project, we took inspiration from the "Longitude Problem" that led to invention of the first practical marine chronometer by John Harrison in the 1700s. Our challenge to the students was to design and build marine chronometers using low-cost, desktop 3-D printers that Thayer shipped to students' doorsteps.

—SOLOMON DIAMOND
Associate Professor of Engineering

For ENGS 12 [Design Thinking] and the Senior Design Challenge, we went back to first principles: What is it that's really important about hands-on work?

One thing is instilling the designer-engineer mindset of thinking by doing. Physical manipulation of objects and materials can be an important, insight-generating strategy. You can think with your hands and get great feedback, even if all you have to manipulate is simple household stuff. The first Swiffer prototype was made by duct-taping a Mr. Clean bottle and a windshield squirter onto a sponge mop. Like this example, we adapted projects to be realized with simple materials students might find around their houses.

Beyond physical prototyping, collaboration is important. While this is trickier, virtual tools help students stay connected and work together. We devised activities that allow students to build meaningful friendships, which are the foundation of fantastic collaborative relationships.

—EUGENE KORSUNSKIY,
Assistant Professor of Engineering

The "how" is a day at a time. I taught Mechatronics, which is typically a lab course, online. I redeveloped the entire course. Because I anticipated the online move about 10 days before it happened, I was able to order parts before the rest of the world, and they shipped from California the day before the state's stay-at-home order went into effect. We had a packing extravaganza—kits for autonomous robots and assembled, self-balancing robots with 9-axis sensors—and shipped all but one kit the Friday before classes began.

The first lab was altogether different, but everyone was able to do it successfully. We went through and troubleshooted every step together, and students used chat to help each other. Overall, I found it to be much like my first year of teaching: just a step ahead of the students.

—LAURA RAY
Professor of Engineering
Senior Associate Dean, Faculty Development

In early March, a group of graduate students approached Professor Margie Ackerman and made the case that the antibody work we were doing with HIV, polio, malaria, and other infectious disease pathogens could be adapted to investigate SARS-CoV-2 infections. Because our platforms are particularly good at looking at mucosal antibodies—which are secreted into the respiratory tract where coronaviruses take root—and capture a broad profile of an individual's immune response, we decided to adapt our research to COVID-19 to better understand the types of antibodies people are generating from SARS-CoV-2 infections and where in the body those antibodies are observed. Because the technology was in place beforehand, it was a pretty straightforward shift once we had the right reagents and resources. Using this platform to identify the antibodies responsible for improving a person's health would not only inform vaccine design, but it could also lead to therapeutic agents that can be developed commercially to help sick people recover.

—JOSHUA WEINER G'14
Research Associate and Project Manager,
Dartmouth Antibody Lab

I've had the chance to work with the Dartmouth Emerging Engineers undergraduate support group, and we shifted our TA program to offer remote help sessions. I'm also one of the co-advisors for Graduates in Need of Decompression, which focuses on mental health and well-being. The student leaders compiled a list of online, free resources for stress management, entertainment, nutrition, fitness, and more. The Thayer Community Builders and Wellness committees are exploring ways to keep the community remotely engaged. While it has been an adjustment, I am constantly impressed with the Thayer community and how faculty, staff, and students have made this possible.

—JESSICA MOODY
Administrative Coordinator
Academic & Student Affairs

Launching two online courses has been an interesting and all-consuming challenge. We've found that it's important to script everything, think through the whole class experience, and prepare for every step. We added several COVID-19 talks to ENGS 5 [Healthcare and Biotechnology in the 21st Century] to better understand the pandemic as well as technologies related to vaccines and diagnostics. We thought it would be a great opportunity to engage with a national community of experts who are part of the extraordinary personal and professional network of Dr. Joseph Rosen, who co-taught the course. He's deeply knowledgeable about the requirements for a comprehensive response plan to take care of medical needs during national emergencies, which is what we need right now.

—PETER ROBBIE
Associate Professor of Engineering

From 1999 to now, I've been working on pandemics, studying basically every biological event in the last 100 years. When I was asked by Peter Robbie to give a section on COVID to the ENGS 5 class, I put together 10 lectures by 10 experts on COVID-19. The students have been very excited about the new material. We were asked to expand our enrollment from 46 to 100. The course registration opened up at 8 a.m., and we had 100 students by 8:30 a.m. I thought that was pretty impressive.

—JOSEPH ROSEN
Professor of Surgery
Geisel School of Medicine,
Adjunct Professor of Engineering,
Senior Lecturer

All at once we had to reshape how we in the MShop would deliver hands-on, educational experiences. We'd already been working to upgrade our 3-D printing and laser-cutting resources, we were able to provide services for students' CAD learning and project models. They send us digital files; we vet them and send them back parts. For the more advanced courses, our team has put together kits, learning plans, and instructional videos. Students seem excited to realize their ideas through this collaborative model.

We are also part of a greater effort to support our medical community through the building of personal protective equipment. These are difficult times, but we find it satisfying to address the challenges in supporting both our students and the greater community through innovative engineering and teaching.

—LEE SCHUETTE
MShop Manager of Operations

“THE TERM WAS ALL ABOUT FLEXIBILITY.”

—PETRA BONFERT-TAYLOR

Traditionally, my work has primarily focused on external communications and marketing. When the decision was made to shift to remote learning, I shifted toward supporting instruction and internal communications, specifically assisting faculty with recording and preparing material. It has been tough to pick up and change everything so quickly. I'm glad my skillset has been helpful as we all go through this challenging period.

—CHARLES SPYDELL
Video Production Specialist

Part of my responsibility was to assemble 70 lab kits. We shipped boards and miniature laboratory benches students needed to build, test, and debug real circuits. We even sent them Thayer School stickers! Working with these exceptional students, as well as faculty and staff, has been an absolute joy. The community has come together as a unified, coordinated front. I'm grateful for the dedication of my colleagues and the resilience of my students.

—BENJAMIN DOBBINS '18
Digital Electronics Lab Instructor

The need to retain hands-on, interactive learning caused us to pivot quickly. We now deliver breakout sessions and groups discussions on Zoom. Normally, students would have access to an electronics lab with a full suite of test instrumentation. And though we couldn't send our students the entire lab, we realized we could help ENGS 22 [Systems] and ENGS 31 [Digital Electronics] students set up home-based labs by sending them Analog Discovery 2 modules to allow them to analyze their circuits.

I ran one of our first lab sessions from a very empty MacLean. Through the camera, I said, "Welcome to Couch Lab. It's a little quiet here now, and I'm going show you what it looks like." I rotated the camera through the lab and added, "I wish you were all here now." I got lots of smiles.

—CHRISTOPHER LEVEY
Director, Safety & Instructional Lab

Computing Services shifted to remote learning nearly overnight. We identified and developed technologies, partnering with faculty and staff to convert classes on short notice. Administrative assistants became videoconference experts, helped test Zoom, and acted as meeting co-hosts. Faculty unfamiliar with new technologies learned and practiced for online classes and lecture recordings. After three weeks full of challenges, we watched closely to see how Zoom would perform, scrambling when things inevitably went wrong. Overall, the massive shift went smoothly. Students experiencing their own technology challenges—such as bad internet, broken computers, and even no computers—were resourceful, helpful, and understanding as we helped them remotely. Everyone's positive approach and energy were just what we needed. One example of this was when a professor said before classes started, "I got this. I'm going to figure out how to do this. I'm energized to make this happen."

—MARK FRANKLIN
Senior Director, Computing Services

TOP: Kitchens became make-shift classrooms and labs during the spring term. For the culminating lab for ENGS 147 Mechatronics, students used parts shipped to their homes to design a feedback controller to stabilize a mini-Segway.

For ENGS 20 [Introduction to Scientific Computing], my biggest goal was to give students the social support they needed so desperately. Students need to interact with each other—especially my first-years, who are still so new to Dartmouth and Thayer. So I broke up my 100 students into groups of four or five.

Students prepare for class by watching short preparatory videos and taking quizzes. During each synchronous meeting, groups are sent into breakout rooms to collaboratively work on coding assignments. My team of Learning Fellows rotates through these sessions to assist, then I call students back into the main room and go over solutions. They can ask questions via the chat feature monitored by the Learning Fellows. I keep track of their understanding with quick polls. After class they have homework assignments, and I have a team of TAs who run help sessions every day. Class is pretty similar to how I normally run it, except we see each other over Zoom rather than in person.

The term was all about flexibility. Everyone went out of their way to join forces, brainstorm, and experiment to make this happen. I am so proud to be part of this amazing Thayer family.

—PETRA BONFERT-TAYLOR
Professor of Engineering

Alumni News

FROM AROUND THE WORLD

spotlights

Team Leader

"Drone" was a new term when **Philly Croteau '10 Th'10 Th'11** joined Physical Sciences Inc. to develop small unmanned aerial systems (sUAS). The Andover, Mass.-based company has since expanded activities to InstantEye Robotics, where he heads engineering operations. "It's founded on the ENGS 21 approach," says Croteau. "The skills learned to meet tight timelines across multiple domains in a small group leads to very effective systems engineers." His cross-functional team exemplifies this philosophy, with Thayer alums bringing various talents to the table: **Louis Buck '10 Th'11 Th'13** leads the software team, **Dave Manegold '02 Th'07 Th'08** heads system controls, and **Jordan Nesmith '11 Th'12** oversees mechanical development. The group is focused on designing and producing sUAS for the military, law enforcement, and first responders. The U.S. Civil Air Patrol used their units to survey damage in the Bahamas after Hurricane Dorian last summer. The U.S. Marine Corps, along with all other branches of the U.S. military, has fielded InstantEye systems. In the works is a prototype to detect radiological or nuclear threats and a compact unit that uses sonar, cameras, and onboard gyros to map indoor spaces. On the horizon Croteau sees opportunities to refine the InstantEye systems to better support force protection. "The underpinning goal is to deliver high-quality kits to the men and women who put on Kevlar to go to work," he says. "Our overall mission is not to create a catchy gadget, but rather to develop a system that is tailored to the folks protecting us and improve their chances of getting home safe to their families."

My vision is to build more empathetic and equitable public services through the lens of design thinking and design processes"

—DEVYN GREENBERG

"Design Thinker"

Human-centered design minor **Devyn Greenberg '17** is preparing to pursue a joint master's in business administration and public policy as a Stanford University Knight-Hennessy scholar. "My vision is to build more empathetic and equitable public services through the lens of design thinking and design processes," says the government major. At Dartmouth, Greenberg learned how to "immerse myself in diverse settings and bring a learner's mindset to those spaces." She participated in a foreign study program in Morocco, served as an intern at the White House, was an exchange student at the University of Oxford, and worked with incarcerated women in art and theater workshops. After graduation, she was a Fulbright Scholar in Rabat, Morocco, where she taught English at the National Architecture School and volunteered at the Moroccan Center for Innovation and Social Entrepreneurship. She credits the design thinking course ENGS 12 with her innovative mindset: "I'm a passionate design thinker who dreams of building radical collaboration around our toughest global issues."

▼ Xinzhang "Andy" Li Th'96

Groundbreaker

Xinzhang "Andy" Li Th'96 did some heavy lifting as project manager for the lowering of historic 3900 Wisconsin Avenue in northwest Washington, D.C. Developers converting the former Fannie Mae headquarters into a Wegmans-anchored development needed to move the entire foundation underneath the 60-plus-year-old building to make way for the grocery store. Li, senior associate with structural engineering firm Tadjer-Cohen-Edelson Associates Inc., was charged with safely lowering the existing basement slab foundation 7 to 12 feet to create the supermarket's required ceiling height. "To the best of my knowledge, there has never been a similar project done in the U.S. construction industry," says Li. He modeled the building using the RAM structural system 3-D program. The goal was to prevent damage to the existing foundations while they supported the building. He created an open space by removing 11 columns and designing new mini piles around the existing foundations to temporarily sup-

On the Job

ERIC DIN '14 TH'16 | HIVE BATTERY LABS CEO

"At Hive, we build quality control technologies to help battery cell manufacturers streamline high-cost bottlenecks in their process."

The Dartmouth Formula Racing 2014 team captain helped build Thayer's all-electric race car, a feat that earned him a spot in the research lab of Professor Jason Stauth Th'00 investigating electric vehicle (EV) battery management systems. As he pursued an MS in electrical engineering, Din also learned how to design and debug circuits with the help of PhD candidate Christopher Schaef Th'16. When he graduated, Din, his two mentors, and Matt Bossart '14 Th'15 founded Seattle-based Hive Battery Labs to improve Lithium-ion battery diagnostics.

What are the potential applications of your work?

The viability of EVs—an important part of our clean energy future—is threatened by the high cost of batteries. At Hive, we build quality control technologies to help battery cell manufacturers streamline high-cost bottlenecks in their process. Our key innovation is the ability to embed advanced electrochemical diagnostics into the first charge of a battery to build better batteries faster.

Can you share some recent highlights?

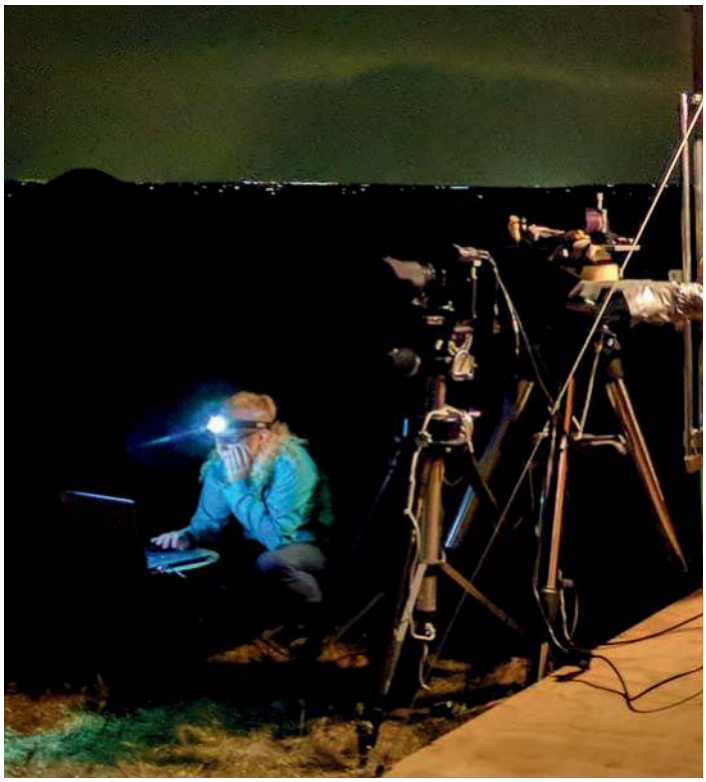
We participated in the 2019 LG Chem Battery Challenge, a technology scouting competition hosted by one of the top EV battery manufacturers in the world. We placed third out of 129 teams across 27 countries and were flown out to South Korea to meet with LG Chem's R&D, engineering, and manufacturing teams and get a better sense of how our technology can help their business. Another highlight was working at one of the world's biggest EV battery manufacturers last August. It was only five weeks from initial conversations about experiment design to being in their Asia labs testing their cells.

What startup lessons have you learned?

The team is absolutely one of our strongest assets. When we launched Hive, the team was entirely electrical engineers. We learned pretty quickly that customers were not interested in more data; they needed to understand the data. Now, we have a small but mighty team of five whose expertise spans power electronics, electrochemistry, data science, and software engineering. It has taken us a while to find the right skills, but we are now well suited to grow and deploy the technology.

—Interview by Theresa D'Orsi

spotlights



◀ Emily Hannah '16 works at the Table Mountain Test Facility just outside of Boulder, Colo., to align laser beam paths at night.

▼ Jeff Hebert '04 Th'06

port its 108 columns, remove the existing foundation, and extend the columns with new foundations. The engineering feat resulted in less than a few millimeters of settlement and no new cracks. The $640-million mixed-use development is scheduled to open in 2022.

The Visionary

Future battles will be fought with new tools using new rules. That's the premise behind the latest book by **William Davidow '57 Th'58**. In *The Autonomous Revolution: Reclaiming the Future We've Sold to Machines* (Berrett-Koehler Publishers), he describes how the rise of artificial intelligence and virtual environments are ushering in an epic cultural transformation as decisive as the Agricultural and Industrial Revolutions. Davidow has the Wall Street cred to draw on: He was Intel's senior vice president of marketing and sales—credited with inventing modern high-tech marketing—and cofounded the venture capital firm Mohr Davidow in 1985. Now he's considering how companies can meet emerging challenges as AI-based machines replace humans and online environments gather data that can be used in cybercrime and propaganda. His recommendations—such as using taxes to control irresponsible internet behavior and enabling people to put their data into virtual "safety deposit boxes"—may offer the tools to thrive during the next revolution.

Bright Light

Emily Hannah '16 has been focused on lasers since earning an engineering sciences degree. She built LIDAR lasers at Bridger Photonics after graduation, and now pursues PhD research at the University of Colorado Boulder on the effects of turbulent air on the propagation of lasers. "We see the effects of this in the twinkling of stars as well as in heat waves over a road on a hot day," she says. "Optical turbulence has a particularly deleterious effect on laser ranging, or LIDAR, where distance is measured using the time-of-flight of laser pulses." It's a field that has tremendous implications as LIDAR is increasingly used to map land and water, model pollution, and drive autonomous vehicles. Hannah recently earned a National Science Foundation graduate research fellowship, and she anticipates a career studying optics at either a national lab or in industry. "Dartmouth and Bridger Photonics have helped contextualize academic research for me: I often think about the impact of sometimes esoteric research efforts on broader industry and technology trends," she says. "It's hard to overemphasize the importance of quality writing and good storytelling in scientific research."

New Reality

As the new president of Synapse Product Development, **Jeff Hebert '04 Th'06** is more job coach than engineer. "I've always tended to assess my performance based on my personal output, but this new role prioritizes enablement and communication. It's about how I set other people up for success," says Hebert, who oversees about 160 people in offices in San Francisco, Orlando, and his home base in Seattle. He started at Synapse 10 years ago as a project manager, then moved to VP of engineering. "One of my earliest projects at Synapse was with Nike," he says. "We embedded force-sensitive resistors along with inertial sensors into shoes to detect foot pressure and motion for basketball and training with custom algorithms running between the shoes and on a mobile phone application." Hebert sees more opportunities to create innovative hardware to connects users with the digital world. "People will always be the center of the equation," he says, "with input mechanisms like gesture recognition and eye tracking as well as broader sensory inputs that add contextual awareness to the rudimentary digital assistants we know today, such as Siri and Alexa."

The Enforcer

Engineering sciences major **Jim Payne '81** credits his technical training for his ability to navigate the environmental laws governing the United States. "Every day my Thayer education has helped me counsel and litigate amidst complex scientific and technical topics," says Payne, currently deputy general counsel for the U.S. Environmental Protection Agency, overseeing legal advice and litigation across the federal environmental statutes. He previously served as deputy head of EPA's Midwest office in Chicago and general counsel for its south-central office in Dallas and conducted environmental enforcement and defense litigation at the U.S. Department of Justice and the Ohio Attorney General's Office. His favorite case to date: New York v. United States, where the U.S. Supreme Court ruled against a federal statute that compelled each state to develop a disposal facility for radioactive waste generated within the state. "The court relied on my amicus brief filed on behalf of 14 states and struck the compulsory provision, holding that state officials are accountable to the citizens who elect them and the Tenth Amendment protects against such federal control," he says. "At Dartmouth I set a goal to testify before Congress on improving environmental

protections. I was happy to meet the goal when I testified on improving environmental protection and worker safety in the nation's nuclear weapons complex."

Big Green Legacy

"I'm sort of green all over," says **Jim Wooster III '59 Tu'60 Th'60**. His father, James '26, and uncle, John '30, ensured he knew about Dartmouth growing up. And although he visited other campuses, "nothing could surpass Dartmouth," Wooster says. "So, there I was—and here I am!" Sixty years after graduating, the Hanover resident's ongoing commitment to the College and its community has earned him a 2019-20 Dartmouth Alumni Award. Since retiring from a career with New York Telephone, Wooster has served as a board member of the Hanover Conservancy and the Visiting Nurse and Hospice of Vermont and New Hampshire and overseen downhill ski racing for the winter Special Olympics. The avid hiker "adopted" a two-and-a-half-mile stretch of the Appalachian Trail that runs through Hanover. He has also served as alumni councilor, longtime class agent, and admissions interviewer and was named the 2003 Class President of the Year. And as the head of a Big Green family—including two sons, two daughters-in-law, and one grandchild—Wooster says, "I just really feel part of the whole Dartmouth community."

Timely Connections

Radio frequency identification (RFID) "is one of the enabling technologies for the Internet of Things," says **Ken Horton '76**, who has worked in the field since 2008. "Businesses can automatically gather real-time information about their assets and their processes." To capture that competitive edge, he cofounded Vizinex in 2012. The company was highlighted as a 2019 Top Supply Chain Project by Supply & Demand Chain Executive magazine, and he reports revenues are up 500 percent since its first year. Medical devices are Vizinex's biggest market, and he expects that trend to continue. For example, the company's RFID has been used to pair a "parent" (the brain) device to "children," the scopes or actuators that touch a patient during a procedure. "This enables the parent to properly use the child device and to track the child device's life cycle," says Horton. "When the procedure is complete, the child device will be cleaned and sterilized in preparation for the next use." As CEO of the Bethlehem, Pa.-based firm, Horton handles sales and marketing and oversees 16 people, including nine in manufacturing and three engineers. The engineering sciences major says working with the right people is essential: "The successful teams I have been on or led have consisted of self-starters who understand their role and their objectives, and they can get to those objectives without a lot of prodding."

▼ Ken Horton '76

On the Job

SANDY BEAUREGARD TH '07 | SUSTAINABILTY DIRECTOR

"I get to work at the intersection of policy and science every day."

Sustainability is a team effort at Colby College. Beauregard, who came to the leadership role in 2017, helps define goals, refine long-range plans, and develop performance metrics for the 2,000-student campus in Waterville, Maine. She oversees 20 student employees and shares offices with the directors of capital projects, operations and maintenance, and business and administrative services. "Sustainability and resource conservation are core values," she says, "so leadership is diffuse and collaborative."

What does a typical day look like?
I would have a meeting or two about current capital projects in various stages of planning; work on an energy-efficiency project to reduce consumption in existing buildings; and connect with sustainability leaders at schools around the country. I also meet with students. For example, I recently met with a student who was working with an economics professor to evaluate policy strategies to encourage forest landowners to manage their woodlands for carbon sequestration. He wanted to learn how Colby evaluates and purchases carbon offsets.

What is one of your goals for the coming years?
Colby achieved carbon neutrality in 2013, the fourth college in the country to reach this milestone. A primary goal is to maintain carbon neutrality through significant growth—a 350,000-square-foot athletics center is under construction and a new center for creative and performing arts is expected to open in 2023.

Can you share a success story?
Expanding our compost program, which was previously only in the dining halls and managed by dining staff. As a result, much of the campus community did not engage with composting in any meaningful way. We have expanded the program to venues that have catered events, which allows much of the campus community to participate. The effort highlights Colby's model of distributed responsibility, as it relied on cooperation among our grounds department, the campus events office, the facilities services staff who do all the event setup, the sustainability office, and dining services. *—Interview by Theresa D'Orsi*

just one question

Q. What advice would you offer to new graduates?

Learn statistical analysis and management accounting. Marketing and product service development is a team effort, so analyze the businesses of top suppliers, competitors, and customers. See to your company's interests first, especially your boss's, and only then to your own. Make sure that your boss thinks you are being under-paid. Finally, you joined the company because of its growth potential: If you can't help make it succeed, look elsewhere!

—Tom Harriman '42 Th'43

Keep in touch with your Thayer contacts, both faculty and fellow students. I did, and it served me well throughout my 55-year working career.

—Warren Daniell '48 Th'50

Seek employment where you will have access to a mentor. Working for and with someone you admire, trust, and respect can provide the basis for a successful career and a life well-lived.

—Howard Jelinek '60 Th'61

Make and stick to a plan for lifelong learning.

—Neil Drobny '62 Th'64

Don't forget to look at federal service. The U.S. Defense Intelligence Agency, FBI, CIA, etc., have engineers who frequently work on top-secret, cutting-edge stuff. As a mere captain in the Air Force I was in charge of a team designing an intercontinental ballistic missile (ICBM). I got to do work that directly influenced the deployment of America's ICBMs and traveled around the country briefing generals and admirals. It was pretty heady and exciting stuff.

—Ward Hindman '65 Th'68

Ask the question, "What can I do that will help?" At Thayer, we were often told that engineers make the world better. That was a very cool idea at the time. One thing I have learned in my long practice is that I can do different things, and the things that give me most satisfaction are those that help the most. I also learned that I got (or had) to choose among lots of options, some with more potential than others. Engineering is an old profession, and for millennia engineering was in support of the military. The first non-military school of engineering, the school of "génie civil," or non-military engineering, was in Paris in the time of Napoleon, when there was finally enough societal money to do something for the people. We were told and were proud that Thayer was the second school of civil engineering in the United States, after West Point. Civil engineering creates the fixed physical wealth of society, which is incredibly cool. Today, a number of other fields of engineering create other kinds of wealth.

—John Kunz '65 Th'66

Really know mathematics cold. Mathematics is the basis for all science and engineering. Read a lot in your field and neighboring fields. You must keep up with the latest developments; Google and Wikipedia are not substitutes for a good technical library. Be able to write a good email, memo, and technical documentation. Be able to give presentations that are informative with no "fluff," so consider a course in public speaking.

Always behave ethically with everyone—whatever the cost—even if those around you do not. Don't be selfish, greedy, egotistical, or desire power (the Ten Commandments are a good guide). A good reputation takes years to build and can be destroyed in seconds.

Be flexible—the world is changing rapidly, and you have to be able to keep up. Don't be afraid of getting out of your comfort zone and doing something new.

—Sidney Marshall '65 Th'72

Find a place to grow. This could be a small business, where you confront new problems daily, or it could be a large organization, where you can watch and learn from experienced coworkers. Or you could take on something on your own, such as with design or software development. If you end up somewhere you can't grow, find something somewhere else.

—Mark Tuttle '65, Th'66

My advice is the same advice that I was very fortunate to get from my first "boss." In my case, he was the captain of the first submarine I served on when I reported onboard after completing my nuclear power and submarine training. He said, "It very important that when problems arise—and they always will—that you communicate them promptly and objectively, but also try to make sure you never take a problem to your boss without having thought through the issue and having a recommendation to offer as to how to deal with the problem."

—Clinton Harris '69 Th'70

Treasure those aspects of your time at Dartmouth that make your undergraduate engineering experience very different from the experience of engineers educated elsewhere with whom you will interact. It's a gift I value as we take collectively face some little virus that has managed to turn our world upside down.

—Brian Hyde '70 Th'71

Find a job you will enjoy doing. When you get out of your car in the parking lot and find it hard to walk into the building, change your job. You spend too many hours at work to do something you do not enjoy and feel is not worthwhile.

—Duncan Wood '70 Th'71

Take time off between school and your first job and between jobs. It's often the only time you can get a good block of free time.

—Richard Akerboom '80 Th'82 Th'85

Be confident in your ability to tackle big challenges. Dartmouth and Thayer prepare you amazingly well with state-of-the-art knowledge, strong problem-solving capabilities, and tremendous work ethic. But be humble in how you go about conquering problems and taking on projects. No one likes a know-it-all. Let your good work speak for itself.

"Look for new challenges every few years—this will keep you learning, stretching, growing."

—MARK BUNKER '82 TH'83

You will also make some mistakes—everyone does—and that's okay. Learn from them and move forward. Be positive and collaborative. Coworkers will gravitate to your energy and enthusiasm. Look for new opportunities and challenges every few years and pursue them if they don't come your way in your current position or company. This will keep you learning, stretching, growing, and highly motivated—and allow you to find your true passion. Doing what you love to do every day and achieving your goals in life, not money or fame, is the ultimate success.

—Mark Bunker '82 Th'83

Make sure to take advantage of the Thayer School-Dartmouth network. No matter where you want to go or what you want to do, there is someone out there you can contact who will most likely be more than willing to offer guidance, advice, and potentially opportunity to pursue your career and dreams.

—Bill Dunham Th'84 Th'87

Always strive to meet the highest ethical standards of your profession. And treat all coworkers, colleagues, and the public with dignity and respect.

—Kurt Egelhofer Th'84

Use your talents to contribute to society in a positive way and keep learning!

—Andy Crowe '85 Th'86

If possible, find a place to live that's east of your office, not west. I live almost directly west of my office, and every morning I'm driving to work facing into the rising sun. Then, every evening when I leave work, I'm driving home facing into the setting sun. It makes for a wholly dispiriting daily commute.

—Gabe Farkas Th'01

Your career is made up of a lot of steps—some sideways, some big ones forward, some backward. But they all tell your story. So, have an attitude of gratitude and learning throughout it all. Continue to ask yourself: What can I learn in this chapter or this role? You are in a reality now where everyone wants you to have experience, but you are just starting off. Be eager to learn and be confident and humble at the same time. Remember that careers are marathons, not sprints.

—Brian Mason '03 Th'04 Th'05

Focus on people, not just the engineering. Any significant accomplishment requires collaboration, communication, humility, and empathy.

—Jeff Hebert '04 Th'06

Don't let the traditional engineering path be the only thing you consider. Thayer prepares you to think strategically about problems, so use that to pursue your passions. In my case, that is related more to foreign policy than traditional engineering. Do not underestimate your ability to write and convey complex ideas to wide audiences—most engineering schools do not emphasize that as much as Thayer does.

—Alison Stace-Naughton '11 Th'13

Work on your communication clarity skills and learn how to write short emails with no ambiguity. Your colleagues will have a word limit—and it's shorter than you think. That's why they make you write executive summaries; keep practicing and play the game well.

—Matthew Reynolds '13 Th'14

Don't be disheartened by the "do what you love" mantra if it doesn't apply to you. If you get to do what you love, great! If you're not quite there yet, figure out a path to where you want to be and start walking in that direction. It may be a long walk and you may have to push yourself on weekends and evenings to reach your goal. It's important that you don't compromise your mental health in the process by being disheartened. And remember that not doing what you love for a living is not an excuse for poor work ethics.

—Shadab Khan Th'16

Even in these trying times, remember that the world is your oyster. You can do anything you set your mind to.

—Sreevalli Sreenivasan Th'17

Not everyone will have their dream job or the life they dream of right out of college or grad school. So be patient with yourself and do not let your first experience make you lose sight of your potential. Stay focused and do your best to maximize every opportunity that comes your way. There are no little opportunities if you receive with thanksgiving and make the best out of them. Focus on acquiring and building skills that are valued in every industry: the ability to lead with or without authority, communicate thoughtfully, collaborate effectively with others, provide thought leadership, and, more importantly, work with integrity. These will set you up for a lot of opportunities. Invest in building meaningful professional and personal relationships. They always yield better returns. Wishing you success in life and career.

—Olusegun Amusan Th'18

Be open to working in small companies that may be relatively unknown but that offer a chance to practice what students have learned in class. For me, this meant designing circuits using industry-level software and becoming familiar with professional engineering practices. As a result, I have continued to perfect my major, and this allows me to move up in my career. A larger company may offer limited exposure to new hires and they may be overlooked initially.

—Ebrahim Najam Th'19

thayer notes

1940s

Warren Daniell '48 Th'50: Dot and I have moved into Newbury Court, a retirement home in Concord, Mass., where we've lived since 1955. Lots of Harvard and MIT people around, but we're enjoying the place and holding our own.

1960s

Neil L. Drobny '62 Th'64: At the end of the current semester I am "retiring" from a 15-year second career as an academic. Serving as a senior lecturer in the area of sustainability and corporate responsibility at the Ohio State University Fisher College of Business was by far the most rewarding endeavor of my professional life. My wife and I are moving to Kalamazoo, Mich., to live on a lake. I plan to stay engaged 20 to 25 percent of the time with students and like-minded business professionals at Western Michigan University, which has a strong sustainability culture led by its business college.

After originally retiring from consulting, I thought it might be interesting to try teaching. My supposition was that it might be more satisfying to work with the next generation of CEOs, rather than the ones I had consulted for who wanted me to do as little, as cheaply, and as quickly as possible. That turned out to be the case. Frequently, I get a call or an email from a former student telling me about a promotion or some career event they traced to an experience they had in one of my courses. That is the best kind of performance review.

Looking to the future, the horizon is very cloudy with the advent of COVID-19. Early in 2020, sustainability momentum in the business community was strengthening. Whether that sort of thinking will take a back seat as we strive to right the ship post-COIVID-19 remains to be seen. A more hopeful outlook is that we may learn a lesson about the need for cooperative, science-based efforts to deal with global crises such as climate change and that will add a spark to sustainability initiatives.

Ward Hindman '65 Th'68: There is no longer too much engineering for an old retiree. My latest big project was helping my grandson build a Spartan shield using cardboard, papier-mâché, and a snow saucer.

Sidney Marshall '65 Th'72: After designing the phase II timesharing system at Dartmouth, I got a job at Xerox in research designing optics for laser printers and designing electronics. After about 30 years, I retired and got a job at Rochester Institute of Technology teaching computer science. I retired again and now keep active calling square dancing, taking piano lessons, and singing in a chorus.

1970s

Brian Hyde '70 Th'71: One memory from Hanover that stands out above everything else is a comparative literature class taught by Professor Peter Bien (Thomas Mann's *The Magic Mountain* and *Death in Venice*, James Joyce's *Ulysses*, Kafka's *Metamorphosis*, Joseph Conrad's *Lord Jim*, Marcel Proust's *In Search of Lost Time*, and Nikos Kazantzakis' *Zorba the Greek*, perhaps more). How on earth did we read all of that and take two other classes? I was too young and naïve to benefit from some of the seemingly abstract concepts addressed in that class at the time. Now I am living some of those concepts and grateful that they found a home 50 years ago. They are the explicit and tangible recollections that have repeatedly made me grateful that I had to obtain an AB from Dartmouth before obtaining a BE from Thayer.

I have worked with a lot of engineers, especially in the field of water resources, floodplain management, and watershed restoration, primarily in Colorado. As it turns out, Colorado's high altitude and relatively dry and sunny weather meant that we had our fair share of tuberculosis sanitoria, much like those facilities in the Alps of Europe where Thomas Mann set his story.

That degree in engineering—and the liberal arts setting in which it all happened—has rewarded me throughout my life. It is how I ended up at the University of British Columbia School

Galllery

1. Sidney Marshall '65 Th'72 teaches his 4-year-old granddaughter, Grace, how to play piano.
2. Mark Bunker '82 Th'83 enjoys family Nordic skiing trips to the N.H. mountains.
3. Olusegun Amusan Th'18 explores Puget Sound in his free time.
4. Sreevalli Sreenivasan Th'17 recently gave her annual Bharatanatyam performance.
5. Alison Stace-Naughton '11 Th'13 lives and works in Ukraine with her husband, Josh.

of Community and Regional Planning after one year of very narrow engineering work designing subdivisions in a rapidly growing Rocky Mountain city. It is also how I conceived the beginnings of the State of Colorado's watershed restoration program, despite a lot of resistance from my non-liberal-arts-engineer boss. It offers a different angle from which to view things and a different set of eyes to try to make sense of the things I see.

| 1980s |

Mark Bunker '82 Th'83: For the past three years, I have been head of digital security at Fidelity Investments in Boston, focused 100 percent on securing our public cloud build-outs in Azure and Amazon Web Services. I run 35 cloud security specialists working in agile teams developing automated preventative, detective, and responsive controls to protect Fidelity applications and client data. It's a very challenging and fast-paced environment. I am approaching 25 years at the firm. Every five years or so, I have been able to move into a different area of technology work and into different roles, such as engineering, architecture, product development, service management, and consulting. Dartmouth and Thayer School prepared me very well to make these moves.

On the personal side, I am active in Nordic skiing and hiking and am getting into road cycling. I enjoy these activities with my wife of 35 years, Sheryl (Brown, class of '82). My two children are grown and on their own: one is a doctor at Beth Israel Hospital in Boston and the other is working at a nonprofit for disadvantaged youth in Boston. We all enjoy taking trips to the mountains of New Hampshire to visit family and ski, hike, and bike.

| 2010s |

Alison Stace-Naughton '11 Th'13: I am currently posted overseas in Kiev, Ukraine, working for the U.S. State Department. It has been a great opportunity and an unusual way to utilize my Thayer degree. Living overseas is a lot of fun and filled with adventure (such as overcoming language barriers and culinary differences). I am currently employed as a foreign service specialist. I use the skills obtained during my college education and directly apply them to promote U.S. government policy abroad in line with intrinsic American values.

The biggest difference between Ukraine and the United States: work-life balance! Americans work way too much. The biggest similarity: Everyone globally loves coffee. They have so many coffee stands here—coffee is a world love!

Matthew Reynolds '13 Th'14: I work in Portland, Ore., as a contract mechanical designer, prototype machinist, and quality engineer at Sherpa Design (sherpa-design.com). We do ENGS 89/90-type projects at the professional level, and my specialty is using manufacturing experience to inform better design choices earlier in the process. In prototype machining, I've spanned a lot of industries. I am working with Dartmouth people based in Utah to help make some of their medical prototypes. They do work for bone implants, so I've helped machine some cool-looking bone parts for them, helped prepare material samples to send to Massachusetts General Hospital for mechanical testing and FDA approval, and done quality control inspections on their competitors' products. Because I used to work in medical device design and a machine shop prior to my job in Portland, I understand the process they're moving through.

I gained experience on user interactions and problem definition by working in Thayer's machine shop, doing a really bad job making my Stirling engine. Just because you made all the parts to be acceptable according to the prints, doesn't mean your Stirling engine will run. My favorite part of the design process is understanding why this happens and creatively coming up with ways to defeat this. Understanding the quality control aspect of my job came organically from just trying to get my head above water in the shop.

George Boateng '16 Th'17: I recently ran SuaCode Ghana 2019, Ghana's first smartphone-based coding workshop. There is a full article at our website, nsesafoundation.org, but here are the highlights: "There is

a new, strong wind blowing along the coast of Ghana. Students are sitting in a classroom, heads down, busy on their phones. No, they aren't WhatsApping. They are writing code and building apps, all from their phones! This is no future aspiration. It's reality, happening now. This new wind is called SuaCode Ghana by Nsesa Foundation! Innovative, revolutionary, game-changing!" I am the president of Nsesa and a PhD candidate at ETH Zurich, Switzerland. In this workshop, I taught coding to 32 students from 8 am to 5 pm for two days, December 23-24, 2019, at the Christian University College Ghana. It was super-exhausting but worth it!

I was also one of the winners of the $5,000 2019 African Union Education Innovation Prize. SuaCode was selected by the African Union as one of the 11 top education innovations from more than 300 submissions. I then presented SuaCode at the 2019 African Union Innovating in Education Expo in Gaborone, Botswana, last August.

Shadab Khan Th'16: After I earned my PhD at Dartmouth, I did postdoctoral research in Boston before moving all the way to the United Arab Emirates. Now I lead an artificial intelligence team to deliver healthcare solutions.

Sreevalli Sreenivasan Th'17: For the past year I have been working on starting a nongovernmental organization (NGO) tentatively called Nourish. India has some of the highest rates of malnutrition, with an estimated 25 percent of the world's population of hungry people. We aim to tackle this issue in a systematic manner, focusing on those who are particularly vulnerable: young children and pregnant women. The government, both at the central and state levels, has various schemes and policies. The National Rural Health Mission and state government's Mid-day Meal Schemes aim to alleviate the problem, and the Anganwadi centers help the urban poor. A lot of NGOs are doing their part, but a lot more needs to be done in an integrated manner. No comprehensive and inclusive program is available on a massive scale.

We are hoping to ensure that all children will be able to eat a healthy diet, as recommended by the World Health Organization. We plan to do this by setting up a network of volunteers and medical teams to assess the need for supplements, medicines, and care in free medical camps. We'll also be coordinating with various government agencies. We are starting in Bangalore once the COVID-19 lockdown is over and hope to expand the program to encompass all of India.

Olusegun Amusan Th'18: I had a career change in the last year from energy to tech and moved from D.C. to the West Coast. I now live and work in Seattle, where I manage technology partnerships between Microsoft and original equipment manufacturers to build and sell intelligent edge and intelligent cloud devices and solutions. Outside of work, I spend my time golfing, building my network, and exploring the beautiful Puget Sound area.

Ebrahim Najam Th'19: I am currently employed at New England Research Inc. (ner.com) in White River Junction, Vt. In fact, I live and commute from Hanover. My job as an electrical engineer assembling rock-testing equipment is really cool and exposes me to analog electronics and signal processing—both of which I studied at Thayer.

Our clients are a mixture of universities across the world (China, Russia, Saudi Arabia, and U.S. universities) and oil companies that have research operations focused on underground exploration. NER makes different product lines, and each product is custom-made for the client. A standard NER system has a vessel (where the core sample from the rock goes) and several electrical probes and hydraulic intensifiers (cylinders) that pump fluid into the rock. This system lets the user perform several geological tests and gather useful data, which can point to a large gas reservoir or rich mineral source. Geology is not my forte, so I will avoid going into specifics.

Business is tough during the quarantine, but the company is small and we are hoping to weather this storm. As an original equipment manufacturer, NER has a loyal client base. I am working on-site in my office, as we engineers have to build these machines from the ground up, and we are doing our best to churn out more products.

obits

Henry Chapman Keck '43 Tu'44 Th'44 died in Pasadena, Calif., on April 4 from a heart attack. His designs are ubiquitous in American life: the bright-yellow hazard lights flashing along construction sites, the soap dispensers and hand dryers found in many restrooms, the glass sugar and syrup dispensers on virtually every diner tabletop. After completing the Tuck-Thayer program, Keck served in the U.S. Navy during World War II and earned a master's in engineering and industrial design from Caltech. In 1951, Keck founded the industrial design firm of Keck-Craig, which emphasized meticulous engineering along with appearance in more than 1,700 products. He lectured on project design and development at Dartmouth, the University of Southern California, and the Art Center College of Design, and shared insights in his 2012 book, *How Design Changed America: An Historical Memoir.* He is survived by his friend, Martha, and several nieces and nephews.

John F. Shearer '44 Th'44 died November 16, 2019, at his home in Naples, Fla. Jack was raised in Burlington, Vt., and attended high school there. At Dartmouth, he was involved in football and skiing, was a brother of Sigma Alpha Epsilon, and participated in the Marine Corps V-12 program. Upon graduation from Thayer, Jack served in the Marine Corps in the Pacific theater during World War II. He then returned to Burlington to spend most of his working career as co-owner of Shearer Chevrolet. Boating and skiing were among his favorite pastimes. He is survived by his wife, Dianne; children Caryl, Janet, and Mark '72; five grandchildren; and nine great-grandchildren.

Charles Terence Quinn '47 Th'47, O.P., who served the Catholic Church as a priest for more than 60 years, died on November 7, 2019, in Dobbs Ferry, N.Y. In May 1943 he enlisted in the Navy, was commissioned as an ensign, and earned a BS in civil engineering from Thayer School in the V-12 program. He then served in the Caribbean before being honorably discharged in June 1947. He entered the Dominican novitiate in 1948 and was ordained a priest in 1955. He joined a mission in Pakistan in 1957 and ministered there for 15 years; in 1988 he began a three-year mission in the Solomon Islands. He also served as pastor of various parishes, including at Holy Innocents Parish in Pleasantville, N.Y., where he was also superior of the Dominican community. He was predeceased by siblings John, Maua, and Eileen.

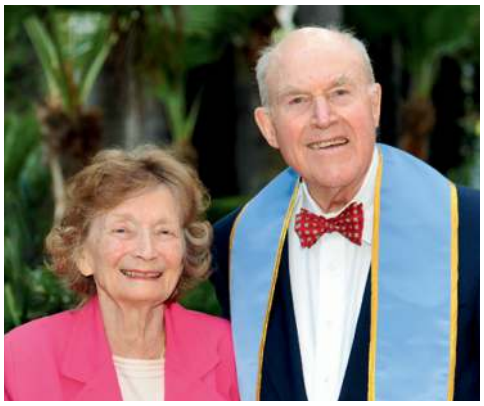
Frederick T. Comstock Jr. '48 Th'48 died on December 16, 2019, in Exeter, N.H. He attended the Newark College of Engineering, joined the Marine Corps, and served in World War II with an engineering demolition unit. Tad then attended Thayer School and in 1951 received a Navy ensign commission in the Civil Engineering Corps. Career highlights included overseeing bridge design and construction with the N.H. Department of Public Works and Highways and structural design with Anderson Nichols & Co. and almost 30 years as an engineer and administrator with the Federal Highway Administration (FHWA). He earned the FHWA's Bronze Medal Award for Superior Achievement, the U.S. Secretary of Transportation Silver Medal Award for Meritorious Achievement, and the N.H. Engineer of the Year Award. He is survived by his wife, Georgette, seven children, and 11 grandchildren.

Robert D. Eckerson '48 Th'49 died on January 27, 2019, in Durham, N.H. An early interest in airplanes led him to enlist at 17 in the Navy, where he learned to fly a Stearman biplane. When the war ended, Bob used the GI Bill to earn a bachelor's and master's in mechanical engineering at Dartmouth. Bob's career took the family from Buffalo and Long Island, N.Y., to Connecticut and Merrimack, N.H. He worked as an engineer for several companies, including Sperry Gyroscope and Rockwell/Boeing. Bob was predeceased by his wife of 66 years, Arlene. He is survived by children Lynn and Daniel and their families.

in memoriam

RALPH CRUMP '66A
— 1923-2020 —

Tireless Entrepreneur



Longtime Thayer Board member Ralph Crump invented technologies that transformed everything from the processes of removing cataracts and purifying water to the development of bar coding and 3-D printing. He secured a dozen patents through the various companies he founded with his wife of 66 years, Marjorie, and was a strong supporter of Thayer School.

Crump, who died March 16 at age 96, launched the field of cryosurgery in 1962 when he founded his first company, Frigitronics, in Trumbull, Conn. He invented a tiny refrigerator that was, for 16 years, the state-of-the-art technology for cataract removal. Frigitronics also invented a soft contact lens originally intended as a drug delivery device that proved so comfortable that it became a consumer product known as the SoftCon lens. In the 1960s he began helping to guide Thayer's entrepreneurial activities when tapped by his former teacher and colleague at UCLA, Dean Myron Tribus. Crump cofounded Osmonics Inc., a manufacturer of reverse osmosis equipment whose basic membrane technology was developed under Dean Tribus by former student Dean Spatz '66 Th'67 Th'68. He was an avid supporter of the work Professor John Collier '72 Th'75 Th'77 was doing on orthopedic implants, as well as the cornea research of grad student Stuart Trembly Th'83. A meeting with Crump prompted Trembly, now a Thayer professor, to start Avedro, which offers a less-invasive alternative to Lasik.

He served on the Thayer Board for 24 years and earned the school's highest honor, the Robert Fletcher Award, in 1979. "Ralph was a deep thinker, action-oriented, a person from whom you sought counsel—and a friend of all of us and Thayer," says Barry MacLean '60 Th'61, a member of Thayer's board of advisors. Board member Charles Nearburg '72 Th'73 Th'74 adds, "Ralph was sharper his last day than I was on my best day, and a lot nicer to boot."

He was predeceased in 2014 by Marjorie, and is survived by his children, Connye, Scott, and Craig and their families.

—Theresa D'Orsi

Hsung-Cheng Hsieh '54 Th'55 passed away on December 2, 2019, in Ames, Iowa, due to complications from a stroke. Born in Taiwan, Cheng studied at the University of Tokyo until 1951, when he received a scholarship to attend Dartmouth. He earned an AB with high distinction in mathematics and then took engineering courses at Thayer School before pursuing an MS in electrical engineering from the California Institute of Technology and a PhD in applied mathematics from the University of California at Berkeley. His career was devoted to teaching and research at Wichita State University, the University of Iowa, and the University of Michigan. In 1968 he moved to Iowa State, where he taught in the electrical engineering department and did research in plasma physics, semiconductor and photonic devices, and the area of lightwave technology. He is survived by his wife, Janet, daughter Hilda, and granddaughter Zoe.

Robert Newell Oxford Jr. '54 Th'55 died on December 7, 2019, at the N.H. Veterans Home in Tilton. At Dartmouth, he was a member of Chi Phi, the rifle team, and the Army ROTC and earned a degree in mechanical engineering from Thayer School. Bob served as a lieutenant in the Army, teaching in the ordinance school at the Aberdeen Proving Ground. Bob then worked at Raytheon as an administrator negotiating government contracts. He retired in 1974 and joined his wife, Allison, in ownership of Impressions Pottery by Oxford. Bob enjoyed many years at the family camp on Rattlesnake Island in Lovell, Maine, where he fished in his Boston Whaler and Old Town canoe. He was predeceased by Allison in 1990. Bob is survived by children Robert, Douglas, and Allison.

Thomas W. Hayden '57 Tu'58 Th'58 of Naples, Fla., passed away on June 8, 2019. At Dartmouth, he majored in engineering sciences and accounting, was active in the Canoe Club and ROTC, and completed the combined Tuck-Thayer program in 1958. After marriage to Dory in 1961, he worked at C.W. Hayden Co., an Auburn, Maine-based manufacturer of industrial, marine, and safety supplies. In 1969 Tom joined his father and brother in the Minnesota Mining and Manufacturing (3M) Co. distributorship. For 31 years he represented the company, driving about 35,000 miles a year, usually with a shotgun and fly rod in the car. Tom served Dartmouth as club secretary and class agent. Tom is survived by Dory and children Stephen and Lisa.

Frank Joseph Killilea Jr. '60 Th'63 of Wilmington, Ma., died on November 20, 2019. At Dartmouth, he was a member of Phi Kappa Psi and the Newman Club, rowed two years on the heavyweight crew, and earned a civil engineering degree from Thayer School. Frank specialized in environmental engineering and worked 30 years with Metcalf & Eddy. He finished his career with the City of Beverly, Massachusetts, serving as the director of engineering and on the Salem-Beverly water supply board for more than 11 years. He was a member of the American Society of Civil Engineers, New England Water Works Association, and the Boston Society of Engineers. He is survived by Katherine, his wife of 50 years; children Susan, Steven, and Thomas; and five grandchildren.

Michael L. Bisceglia '63 Th'64 died November 2, 2019, at his home in Rye, N.Y., of Alzheimer's. At Dartmouth, Mike earned an AB in environmental science and an MS in civil engineering. He played football and was a brother of Phi Gamma Delta. After graduation, Mike worked for Turner Construction and then with his brothers formed Bisceglia Brothers, which was responsible for the development of many municipal buildings in Westchester County, N.Y. He was an active member of his community and served as president and member of the board of education of the Harrison School District. He is survived by his wife, Mary Lou; children Patrick, Teresa, Michael, and Brett; five grandchildren; and his former wife, Elaine.

Melvin M. Shiramizu '63 Th'65 died on January 22 in Lakewood, Colo., of multiple system atrophy. Melvin was born in February 1942 after his father was drafted and sent to Eu-

rope. Shortly thereafter Melvin and his remaining family were forced to evacuate from Salinas, California, to an internment camp in the Arizona desert. His father was killed in Italy. After the war Melvin and his mother and sister relocated to Denver, where Melvin grew up. He attended Manual High School, graduating cum laude, and attended Boys' State. He graduated from Dartmouth, where he was a brother of Phi Tau, and took courses at Thayer School through 1965. Melvin went on to pursue a successful career as a computer manufacturing engineer with StorageTek Corp.

G. Jeffrey Ashworth '71 Th'72 died of cancer at his home in Quincy, Mass., on December 7, 2019. At Dartmouth, he was a member of Phi Sigma Psi and earned an AB in engineering sciences and a BE concentrated in structural engineering at Thayer School. Jeff spent most of his career with Stone & Webster Engineering Corp. in Boston, working on structural and civil aspects of major industrial facilities, primarily electric generation stations, including nuclear, hydroelectric, and fossil-fueled plants. For two years he was the New England regional manager for Vollmer Associates, an engineering firm specializing in engineering and landscape architecture. Jeff is survived by his wife of 45 years, Bonnie, daughters Maryann and Elizabeth and their families.

Darrel R. Gavle '71 Th'72, the former president and CEO Baxter & Woodman Engineering, died on January 23. At Dartmouth, he earned his BS in civil engineering and was a member of Sphinx, Kappa Sigma, and the 1970 undefeated Ivy League championship football team. He moved to Crystal Lake, Ill., immediately after college and spent his career at Baxter & Woodman, retiring in 2009. Outside of work, Darrel loved to hunt, fish, play golf, and watch and participate in various sports. He served on the Crystal Lake library board for more than 20 years, the Library Foundation board, and the Crystal Lake planning and zoning board. He is survived by his wife, Susan, children Dave and Katie and their spouses, and two grandchildren.

| in memoriam |

FOXHALL PARKER '48 TH'49

— 1925-2019 —

Biomedical Pioneer

At age 17, "Foxy" Parker joined the Navy to fly fighter aircraft during WW II.

Bioengineering was a new term when "Foxy" Parker went to work at his father's surgical instrument manufacturing company, Bard-Parker (later Becton Dickinson). It was in the Danbury, Conn.-based facility that the mechanical engineering major learned how new technologies—and the engineering to develop them—could be used to advance medicine.

Parker, who died on December 28, 2019, at age 94, spent much of his life supporting projects at Thayer School and Dartmouth Medical School that used engineering and creativity to solve healthcare challenges. Upon his father's death, he established the Morgan Parker Memorial Fellowship for scholars applying engineering to the needs of the medical profession. In recognition, he was named a Sylvanus Thayer Fellow in 1979 and he received the Heritage Award from the Society of Manufacturing Engineers. He was active with the Dartmouth Society of Engineers and the College's Magnusen Center for Entrepreneurship.

Parker grew up in Katonah, N.Y., on property that is now the Bedford Audubon Society's Bylane Farm. There he learned to ski, hike, and skate—interests he continued to pursue at Dartmouth as a member of Cabin & Trail and the Outing Club. Another great passion was flying, and he entered the Navy after high school to become a pilot. He was initially sent to Hanover as part of the Navy V-12 program. Although he never saw combat with the VS-835 squadron, he learned to pilot everything from a Steerman trainer to the Corsair fighters that became his specialty. While stationed in Pensacola, Fla., he performed nighttime aircraft carrier takeoffs and landings above the rough seas of Guantanamo Bay and practiced dogfight duels and precision maneuvers. Parker remained with the Naval Reserve as he returned to civilian life in 1946, initially working at Grumman Aircraft before returning to Hanover to earn his bachelor's and master's degrees.

Parker is survived by Helen, his wife of 67 years, and daughters Patricia '82 and Mary.

—Theresa D'Orsi

Collaborations

"We are called to lead and help."

—JUNFEI YU TH'19

Answering the Call

Fifty thousand medical facemasks arrived at Dartmouth-Hitchcock Medical Center (DHMC) in mid-April thanks to a group of Dartmouth alumni in China. "We are called to lead and help," says Junfei Yu Th'19. Yu and Dingyang Lu '17, managers at health technology firm Wuhan Xiaoyaoyao Pharmaceutical Technology Co., sourced the disposable surgical masks from across China before shipping them to Shanghai. There, the team did a final check before labeling the boxes with Dartmouth's logo and motto, "Vox clamantis in deserto," for the flight to the States.

"Equipping our staff with appropriate personal protective equipment is crucial in the fight against COVID-19 and accessing supply has been challenging," says Curtis Lancaster, vice president of DHMC's supply chain. "This substantial donation helped supplement our stock at a time when we needed it most."

Yu and Lu were supported in their efforts by the company's Dartmouth alumni group, which includes cofounder Yi Peng '12. "We felt it was time to give back to Dartmouth community because of the severe situation caused by the coronavirus pandemic," says Yu, who earned his BE at Thayer, participated in the TuckLAB program, and worked with Professors Sol Diamond '97 Th'98 and Douglas W. Van Citters '99 Th'03 Th'06 as a Cook Engineering Design Center Fellow. "I am deeply connected with Thayer and Tuck, as I wouldn't be where I am now without my education at both schools."

Since the outbreak, Xiaoyaoyao has delivered more than 200 million masks and other medical supplies across China.

—Julie Bonette

OPPOSITE PAGE: COURTESY DINGYANG LU AND JUNFEI YU

@Dartmouth • Apr 13

A coalition of scientists are working around the clock to improve testing and develop new therapies.

@thayerschool's Jiwon Lee and his lab are trying to understand antibody responses to COVID-19 and identify antibodies with therapeutic potentials. #DartmouthEngineer.

@siddsaran • Apr 29

Congrats @AbramsonAlexis and Thayer faculty on the ingenious ways ENGS teaching is adapted and being done by Zoom...

mailing each student lab equip, miniature boards, or credit cards to buy stuff. I was blown away! Proud to be an alumnus!

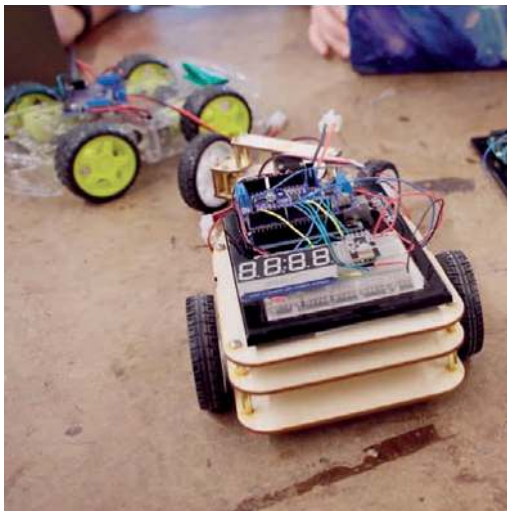
@thayerschool • Apr 30

Former Astronaut Jay Buckey Talks About Dealing With Isolation

Need some help #coping with #selfisolation? Ex-astronaut and #DartmouthEngineering Adjunct Professor Jay Buckey has launched an online self-help toolkit.

@thayerschool

#thayerschool
#inthistogether



New & Improved

Four students helped improve the final project assignment for Dartmouth's new Embedded Systems course in which students program hardware for a model car that has both manual and autonomous modes.

@thayerschool
Shoutout to the support staff in our home offices, helping to reduce stress with daily doses of cuteness, cuddles, and companionship. Pictured: Cleo and workmate Assistant Professor of Engineering Eugene Korsunskiy

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I'm an Engineer and a Humanitarian

"Engineering and humanitarian aid and development really go hand in hand together. I feel like engineers have an obligation to try and solve some of the world's problems."

—PhD candidate Ethan LaRochelle

WATCH LAROCHELLE AND OTHER STUDENTS IN THAYER'S "I'M AN ENGINEER AND..." VIDEO SERIES AT YOUTUBE.COM/THAYERSCHOOL